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THE MINING INSTITUTE OF SCOTLAND.

ANNUAL MEETING.

RALPH MOORE, Esq., President, in the Chair.

THE Fifth Annual Meeting was held in the Hall of the Institute, Hamilton, on Thursday, the 13th day of April, 1882.

The meeting was attended by upwards of 40 Members.

The Secretary read the minutes of the last General and Council Meetings. They were approved of, and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members :—

DAVID DUNN, Coalmaster, Rhinds, Baillieston.
HUGH GRAHAM, Manager, Allanton Colliery, Hamilton.
ROBERT M'LAREN, Manager, Braehead and Newlands Collieries, Baillieston.
JAMES YOUNG, Quarter Iron Works, Hamilton.

The following were nominated for election at next meeting :—

WILLIAM LUKE, Colliery Agent, Prestongrange.
HENRY W. LEWIN, Mining Engineer, Drumpellier, Coatbridge.
JAMES S. JENKINS, 33 Renfield Street, Glasgow.
JOHN HYSLOP, Manager, Heathery Knowe Colliery, Bargeddie.
JAMES MAXWELL, Burnbank, Hamilton.

The Secretary read the following reports :—

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THE MINING INSTITUTE

OF SCOTLAND.

TRANSACTIONS,

Vol. IV.

1882-83.

HAMILTON:
PRINTED BY WM. NAISMITH, CAMPBELL STREET.
1883.

Sn

622.0411
M665

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THE MINING INSTITUTE OF SCOTLAND—BALANCE SHEET.

Abstract of Receipts.

Dr.

1881-82.									
To Balance from last year, ...	...	...	...	...	...	...	£93	18	10
,, Members' Subscriptions, 147 @ 21s,	...	...	...	...	...	...	154	7	0
,, Do. do., 2 @ 20s 9d,	...	...	...	...	...	...	2	1	6
,, Do. do., 2 @ 20s,	...	...	...	...	...	...	2	0	0
,, Do. do., 217 @ 10s 6d,	...	...	...	...	...	...	113	18	6
,, Do. do., 3 @ 10s,	...	...	...	...	...	...	1	10	0
,, Do. Arrears, 3 @ 21s,	...	...	...	...	...	...	3	3	0
,, Do. do.. 5 @ 10s 6d,	...	...	...	...	...	...	2	12	6
,, Do. Subscriptions paid in advance, 2 @ 10s 6d,							1	1	0
,, Advertisements, ...	...	...	...	...	...	...	23	2	0
,, Do., Arrears from last year,						...	4	14	6
,, Sale of Transactions,	...	...	...	...	...	...	13	10	3
,, Received for use of Hall,	...	...	...	...	...	...	0	15	0
,, Interest on Money in Bank,	...	...	...	...	...	...	3	0	3
							£419	14	4

Abstract of Payments.

Cr.

1881-82.									
By Printing and Stationery,	...	...	...	...			£177	15	8
,, Cleaning Hall,	...	...	...	...	...	...	1	15	0
,, Taxes and Gas,	..	...	...	...	...	...	2	14	7½
,, Rent of Hall,	...	...	...	...	...	...	22	8	0
,, Stamps, Trains, &c.,	...	...	...	...	...	...	10	0	6½
,, Deputation to England,	...	...	...	...	...	...	24	0	10
,, Books,	...	...	...	...	...	...	12	4	2
,, Bookbinding,	...	...	...	...	...	...	1	2	6
,, Salaries,	...	...	...	...	...	...	50	13	0
,, Balance in Bank,	...	...	...	...	...	...	117	5	0
							£419	14	4

Examined, compared with vouchers, and found correct.

(Signed) GEO. BISHOP.

(Signed) ROBT. THOS. MOORE, B.S.C., C.E.,

Liabilities.

Nil.

Balance,	...	...	...	...	...	...	...	£142	9 0

Assets.

By Cash in Treasurer's hands,	...	...	...	...	...	...	...	£0	17 1
,, Money in Bank,	...	...	...	...	..	...	...	116	7 11
,, Members' Subscriptions in Arrear,			...	...	...	..		12	12 0
,, Arrears for Advertisements,	...	...	...	...	...	...	...	12	12 0
								£142	9 0

COUNCIL'S REPORT.

The Council, in making their report, have to express their satisfaction in the continued prosperity of the Institute.

The membership at the commencement of the year was 295, and during its currency 104 have been added; owing, however, to the death of 3 members and the retiral of 9 others, the number at present stands at 387.

There have been twelve general meetings during the year, and they were well attended. The August meeting was held at Ayr, at which there was a large representation of members belonging to the West.

By invitation of John Watson, Esq., the members of the Institute visited Earnock Colliery for the purpose of examining the lighting by Swan's Electric Lamps.

The papers read have been fully up to the usual standard, and the discussions thereon were well sustained. The following is a list of the papers read during the year :—

"Description of Dr. C. Heinzerling's Safety Lamp," by Mr W. J. A. Donald.
"Stirlingshire Coals and other Minerals," by Mr Peter M'Beth.
"On a New Hydraulic Pumping Engine," by Mr David Johnstone.
"On Gas Firing, with a Description of the Wilson System," by Mr F. J Rowan.
"Mining Surveys," by Mr T. Lindsay Galloway.
"The Steam Indicator," by Mr J. M. Ronaldson.
"Some Remarks on Mining Inspection in Belgium," by Mr Robert T. Moore.
"Paterson's Indicator," by Mr James Paterson.
"Employers' Liability Act," by Mr John Drinnan.
"Haulage Experience," by Mr Jonathan Hyslop.
"Details of Long-Wall Working," by Mr John Hogg.

A special feature in the Transactions was the Report by a Deputation—noticed in the last report of Council—to the English, Welsh, and Scotch mining districts, on the various methods of propping and securing the roofs and sides. Their report consisted of 72 pages of letterpress and 56 plans and sections of actual workings illustrative of it.

During the year a committee was appointed to examine and report on the different Safety Lamps in use in the district. Their report will be communicated to the Members next month.

It has been arranged for a deputation to visit Shipley Collieries, near Derby, to examine and report on a system of getting coal by the use of caustic lime.

During the year further applications have been made by kindred Societies for an exchange of Transactions with yours, which the Council have agreed to carry out.

The Council beg to draw your attention to the present large number of these Transactions (amounting to 22) which contain valuable and the most recent information on mining and the allied industries. These and a number of books on mining and engineering which have been purchased during the year are open to members for perusal every Thursday evening.

The only donation to the Institute during the year was a book on Mine Drainage given by John Austine, Esq.

The PRESIDENT said the Council had given such a full report, exceedingly neatly put, that there was nothing left for him to say. In ordinary cases, it was the duty as well as the privilege of the President at the commencement of each year's business to make a statement as to the Society. He regretted very much that he had nothing to say at this time, for two reasons. In the first place, he had thoroughly made up his mind not to accept office for another year, because he did not think it was for the good of the Society that one person should be President for more than two years, as was the rule in other Societies; and, in the next place, he had had little time to prepare anything. As to the Report on Propping mentioned in the Report, it seemed to him that they should make some more use of it. They left the propping to the miners in the first place, with a slight regulation on the part of the owners. Well, as they did so, what was there more fitting than to let them know what was doing in other places. He had an idea that every collier should have a copy, and that this might be realised if a cheap edition were printed at a cost of 2d or even 6d. He had no doubt if it was known outside of their own comparatively limited circle, it would be highly appreciated. While saying this, he was quite alive to the value of the other papers. He supposed they would agree that the Council's report should be adopted?

The report was approved of.

The following gentlemen were elected Office-Bearers for Session 1882-83 :—

President :

RALPH MOORE, Esq., Croft Villa, Rutherglen.

Vice-Presidents :

JAMES S. DIXON, 170 Hope Street, Glasgow.
JOSEPH T. ROBSON, Jesmond Villa, Cambuslang.
JOHN M. RONALDSON, Belton Villa, Pollockshields, Glasgow.
JAMES SMART, Angus Lodge, Hamilton.

Councillors :

DAVID ANDERSON, Clydesdale Street, Hamilton.
JOHN AUSTINE, Oak Lodge, Hamilton.
JAMES BARROWMAN, Ardenlee, Portland Park, Hamilton.
ARCHIBALD BLYTH, Bent Colliery, Hamilton.
JOHN DRINNAN, Arden Colliery, Airdrie.
ALLAN GILMOUR, Portland Colliery, Kilmarnock.
JAMES HASTIE, Greenfield Colliery, Hamilton.
JOHN HOGG, North Motherwell Colliery, Motherwell.
JONATHAN HYSLOP, Kinneil Iron Works, Bo'ness.
JOHN LOVE, Haughhead Colliery, Hamilton.
THOMAS SPOWART, Broomhead, Dunfermline.
HENRY TELFER, Overtown and Law Collieries, Wishaw.

Ex-Officio Members of Council :

GILBERT BURNS BEGG, Brandon Street, Motherwell *(Past President)*.
JAMES M'CREATH, 95 Bath Street, Glasgow *(Past Vice-President)*.

Treasurer :

MICHAEL ROSS, Clyde Bridge, Hamilton.

Secretary :

JAMES GILCHRIST, Earnock Colliery, Hamilton.

MR HYSLOP'S PAPER.

The PRESIDENT introduced the discussion of Mr Hyslop's paper on Endless Ropes and Chains.

The SECRETARY (Mr Gilchrist) read a note from Mr Hyslop stating that it was quite impossible for him to spare the time to come to Hamilton to be present at the discussion.

Mr ROBSON thought they would all be very sorry that Mr Hyslop had not found time to attend the meeting that night. A number of gentlemen had expressed themselves dissatisfied, and thought he should have been present at this, the third adjournment of the discussion, especially as he, Mr Hyslop, had not been able to attend before. He hoped, however, that the President would see fit to ask the members to discuss the paper as far as they could in Mr Hyslop's absence.

The PRESIDENT quite agreed with Mr Robson, and would be very glad to hear any gentleman's remarks on the paper.

Mr JOHNSTONE, of Garscaddan, in a communication to the Secretary, says:—Has Mr Hyslop, or any other member, ever during the discussion on Mr Hyslop's paper on "Haulage ascertained, experimentally, the ratio in which the tractional resistance is increased when the fork, by which the hutches are attached to the chain or rope, is placed at the *side* of the hutch, instead of at the centre? I observe from his paper that the latter mode of attachment has been adopted by Mr Hyslop, but the former mode is nearly as common, and some reference has already been made to it in the discussion. When the point of attachment is at the side, the strain upon the rope or chain will tend to twist the hutch, and will cause the flanges of two of the wheels to press against the rails with a force which will be directly proportional to the width of hutch, and inversely proportional to the length of its wheel base. In the case of surface waggon haulage, where the rope runs at the side of the road, and the waggons are attached to it by means of a short coupling chain, this side friction will be still further increased—this increase being directly as the tangent of the angle which the coupling chain makes with the haulage chain. The friction of the flanges of wheels against the side of the rails being not a *rolling* but a *rubbing* one, the additional tractional resistance must, in the case of heavy loads, be something considerable. I am not aware that any experimental data bearing upon this point have been published; but perhaps some of the members may be able to throw some light upon it. This method of side attachment must certainly be much more injurious to the rolling stock and to the road.

STATE
SAN FRANCISCO.

Mr JOHN ROBERTSON, Lanemark Colliery, writes:—I agree with the President's remarks in the last number as to haulage with horses; and I quite agree with him that straight, well-made roads (I would say not less than six feet high) do more to cheapen haulage than many are aware of. Main streets are quite as needful in a coal pit as in a city. I trust you may continue giving out such useful hints, &c.

Mr RONALDSON—I have received the following particulars of haulage by horses at a Colliery near Edinburgh:—The seams worked are four in number, and the pits are sunk to the bottom seam. A cross-cut mine driven to the dip of the field intersects the different seams and enables the coals to be brought out the mine to the pit bottom. From the points where the seams are respectively intersected, levels are driven in the coal by which the coal to the rise is won. The roads along the mine and the levels are all made to rise at a regular gradient of 1 in 250 from the pit-bottom to the level faces, being ballasted with about a foot of freestone; and the bridge rails, weighing 22 lbs. per yard, are laid carefully with a rule. Along these roads an ordinary pit horse can draw out to the pit bottom 8½ tons of coal or other material in one "race," but the ordinary working "race" is 6½ tons of coal. The hutches weigh 3½ cwts., and hold about 8½ cwts. Eight horses are employed, and their day's work consists of drawing 500 tons, an average distance of 577 yards, which is accomplished easily. The cost of doing the above work is as follows:—

Eight Horses, at £30 each—£240. Interest and Depreciation on £240 for 1 day, at 20%, ...	£0	2	7½
Wages of 8 lads, at 2s per day, ...	0	16	0
Provender of 8 Horses, at 2s 3d per day, ...	0	18	0
Saddlery, &c., say	0	1	6
Total cost,	£1	18	1½

Which divided by 500 gives ·91d per ton, or 2·11d per ton per mile.

Mr ARNOTT—Since last meeting I have taken a few notes regarding the endless chains at Dykehead Colliery, belonging to the Summerlee Iron Company. The main and ell coals are won

from a day mine, and the gradients of the chain road, starting from the screening house are as follow :—

89	Fathoms,	1 in	4¼.
42	„	1 „	7.
192	„	1 „	20.
33	„	1 „	100.
95	„	1 „	190.

The total distance is 451 fathoms, or ·512 of a mile, and the average grade against the road is 1 in 12 nearly. Near the inbye end of the main chain, which is in the main coal seam, a cross-cut mine (average gradient 1 in 14) is driven to the ell coal, and the coals from this seam are led a distance of 170 fathoms by a self-acting endless chain to the main chain. The average daily output from both seams is 170 tons, and the cost per day for leading, over both chains, is 9s 8d. Cost of leading coals per ton per mile, the average distance led being ·705 mile, and the average quantity led being 170 tons per day, ·968d. The endless chain in the splint coal seam is $\frac{9}{16}$ inch diameter, and has been working regularly for over eleven years. It delivers the loaded hutches at the pit bottom in such a way as to allow of their being run straight on to the cage, the empty hutches at same time being driven off on to their proper place on the empty side of chain. Starting from pit bottom and going inbye, the chain road has the following gradients :—

85	Fathoms,	1 in	18	rise.
155	„	1 „	14¾	dip.
360	„	1 „	55½	„
53	„	1 „	23	„

The total distance is 653 fathoms, or ·742 of a mile, and the average gradient against the load is 1 in 29½ nearly. At the inbye end of this chain there is a branch chain driven by it, the length of branch road being 73 fathoms, and the gradient against the load being 1 in 33. There are 70,000 tons per annum led by the main chain, the average daily output being 250 tons, and the average cost per day for leading is :—

Inbye end,	5s 0d.
Outbye end, including engineman and bottoming,	8s 5d.
Total,	13s 5d.

Cost of leading coals per ton per mile up an average gradient of 1 in 29½, the average distance led being ·742 mile, and the average quantity led being 250 tons per day, ·867d. The foregoing refers to the cost of labour alone. The steam for engine is taken from the surface, and there is very little labour or expense in maintaining the roadway. Mr Wilson, the manager at the colliery, tells me that when the chain breaks anywhere outside the engine-house at pit bottom, it takes two hours to repair it, and this time is mostly taken up in getting ponies from the face to assist them, and taking them back again. It goes from one to three months without breaking, and breaks fifteen out of twenty times at the driving wheel in engine-house, near which Mr Wilson has a contrivance for catching it, and then it only takes from ten to fifteen minutes to put it right again.

Mr ROBSON—Are we to understand that this cost of under 1d per ton per mile includes depreciation and the cost of everything, or is it simply the cost of the labour of putting the hutches on at the one end and taking them off at the other, and attending to the road? Does it include cost of fuel and firing the boilers for driving the steam engine, &c., so as to compare with the statistics read by Mr Ronaldson, which, I understand, include everything?

Mr ARNOTT—It includes the labour done.

Mr DRINNAN did not think Mr Ronaldson allowed for the depreciation of horses.

Mr RONALDSON—Yes, it includes everything.

Mr TELFER—At page 307 Mr Hyslop says, "The conclusion I have come to is that for general purposes about a mine the endless chain is the cheapest and best;" and at page 311, he says, "All the chains I have worked have been on the surface." I quite agree with Mr Hyslop that for surface haulage the chain is best, and works most economically. I don't think it is the best for general purposes underground. There are one or two objectionable things connected with the endless chain in working it underground. The "tub," requiring to be extra deep, has to be made heavy and strong, as it is generally drawn by the top. This makes it unhandy and difficult to work at the faces; those deep tubs also tend to reduce the percentage of round coal. One of the

greatest difficulties is when the roof is bad and the road is continually requiring timbering and repairs; the getting of timber taken to the place required, and rubbish taken away is sometimes not easily done. For the successful working of chains underground, the road must be perfectly straight, and where there is a change of gradient, it must be done gradually. If this is not attended to the chain is very apt to lift out of the notch in the end of the tub.

I have taken the actual costs of working two endless ropes and one endless chain for a year. The two ropes are in the same pit, and worked by one engine on the surface. One of the roads is 1700 and the other 600 yards long. Near the inbye end of the long road, the coal is drawn up an incline by a fixed engine before being put on the endless rope. There is also a staple for lowering from an upper seam; the labour for working these are included. The chain is in another pit, the engine for working it is at the pit bottom, and is supplied with steam from boilers on the surface. The length of the road is about 800 yards. The work done and costs were as follow:— Work done by ropes, 79,207 tons of coal led an average distance of 1020 yards, at a cost of 4·028d per ton per mile; and by chain, 20,000 tons are led an average distance of 800 yards at a cost of 6·342d per ton per mile.

The PRESIDENT asked Mr Telfer how he accounted for the cost being so much higher than the others?

Mr TELFER said that they could lead three times as much with the same labour. He added that the chain road was pretty nearly exhausted.

The PRESIDENT—You would not say that that was a fair comparison in the matter of chains *versus* ropes?

Mr TELFER—That chain is not a fair comparison with these ropes.

Mr R. T. MOORE—In considering the different methods of haulage along a level road, it must be borne in mind that the force to be overcome is only the friction of the load. This on a well laid underground tramroad is $\frac{1}{100}$, while on railways on the surface it is only $\frac{1}{224}$. There is thus a good deal to be done in improving underground roads before they are brought up to

the standard of surface railways. With a haulage by an endless rope or chain the weight of the rope or chain has to be drawn in addition to that of the load, and when this is carried on rollers the co-efficient of friction is more than $\frac{1}{100}$, perhaps, $\frac{1}{50}$. Thus, in Mr Hyslop's paper, page 314, he says, "That 180 tons were drawn 1500 yards in a day." This is 153 tons drawn a mile. Taking the weight of the chain as 8·6 tons, and its speed as two miles per hour, then 8·6 tons of chain have to be drawn 20 miles in a day, or 172 tons a mile. The power necessary to draw this quantity of material (taking the co-efficient of friction as $\frac{1}{100}$) is ·916 H.-P. There would require to be the same power to draw the hutches and return the empties. Taking the friction of the chain on rollers at $\frac{1}{50}$, the power necessary to draw the chain is 2·055 H.-P. That is to say, the work done in hauling the chain alone, is greater than that done in drawing the load. If the total power be taken as $5\frac{1}{4}$ H.-P., then, taking 15lbs. of coal per effective horse-power per hour, 787lbs. of coal will be required, or the cost for power will be about 1s a day. (In Mr Hyslop's case, the heat being taken from the waste gases from the coke ovens, this cost is nothing.) Although the horse-power necessary to do this work is only 1·83 H.-P., if horses were employed they would not be fully employed in drawing back the empties, and probably four horses would be required. The cost of feeding would be about 8s a day, so that the cost of power as derived from coal is $\frac{1}{8}$ of what it would be as derived from corn. If the road dipped with the load at a gradient of 1 in 200, so that the power to draw up the empty hutch was the same as that necessary to draw down the loaded one, then only half the work would require to be done, and two horses could do it. With the mechanical haulage the horse-power necessary to draw the chain would remain the same, while that necessary to draw the load and empties would be reduced to 1·37 H.-P. The total power would be 3·43 H.-P. or say 4·6 H.-P. The cost of this power would be 11d a day, while the cost of horses would be 4s; so that even under the most favourable conditions the cost of the power necessary for the haulage is less by machinery than by horses. This cost, however, is a comparatively unimportant factor in the cost of a haulage, the chief saving in a

mechanical haulage over horses being in the number of drivers dispensed with, and as the cost for ropes and labour may be said to represent the wages of at least two men, whenever three drivers can be thrown off it is cheaper to employ a haulage than horses. The question of the quantity of material it is economical to employ a haulage for, thus resolves itself into what is the work of horse? and if this be taken as 40 tons drawn a mile a day along a level road, or 80 along one dripping 1 in 200, then, whenever 120 tons require to be drawn a mile along the former, or 240 along the latter, it is cheaper to employ a haulage than horses. As the road gets longer the comparison becomes more in favour of the machinery, as the same number of men is required for a haulage one mile in length as for one two miles. It must be remembered, however, that horses can do shifting at the ends much more rapidly than machinery, and if the roads are so short that the horse can draw all the way, then an advantage is gained in being able to avoid changing the system, and hence it happens that in many cases horses compete successfully with machinery. An ordinary locomotive possesses many of the advantages of horses, and hence haulage by it, especially on a level road, may be the cheapest of any.

Mr BARROWMAN said, in looking at the Kinneil haulage, it occurred to him there was some loss of power in having them going at the same speed irrespective of the quantity going along. However, the advantage of having the fittings all the same size and dimensions, was greater than the disadvantage which resulted in having them all going at the same speed irrespective of the quantity of stuff moved.

The PRESIDENT thought they should have had some other remarks about this important subject, but if there were none it might be closed. He had no doubt Mr Hyslop, from his long experience, had chosen the system which seemed to him to be best, and no doubt any system required to be considered with regard to its application to any place. It depended very much upon the gradients, and upon the quantity, and upon the circumstances which every place had within itself, and that being the case, while this discussion had afforded them a good deal of information as to other systems, and to what a horse could

do, which was very valuable to the institution, he was not inclined to say that they had passed any verdict whatever upon Mr Hyslop's paper further than that it seemed from his own account to be very suitable for the place. With Mr Robson he regretted very much Mr Hyslop had not found it convenient to be present; still, he moved a vote of thanks to Mr Hyslop for the trouble he had taken in preparing the paper. (Applause.)

ON ANNEALING CHAINS:

By Mr D. JOHNSTONE.

In bringing under your consideration the annealing of chains, it may not be out of place to give a short sketch of the history and the processes employed in the manufacture of wrought-iron. Iron is the most useful of all the metals to man, and also the most widely diffused. Only in very rare instances is it found pure, but principally as an oxide or carbonate—all our Scotch ores are of the latter description. Iron must have been known to the ancients at a very early date. We read in the Book of Genesis of Tubal-Cain being an "Artificer in iron," and it is also mentioned by Homer, and other ancient poets, as the following lines from the "Odyssey" will show—

> "And as when the armourer tempers with the ford,
> The keen-edged pole-axe, or the shining sword,
> The red hot metal hisses in the flood."

A piece of wrought-iron, part of some tool used in the building of the great Pyramid, 4000 years ago has been found imbedded in the mortar. It may be owing to the great affinity of iron for oxygen that no very ancient tools or weapons of that material have been discovered, while those of the stone and bronze ages have been preserved. Iron, or rather the compounds of iron, are classified into three distinct kinds, each having very different properties, viz., cast-iron, wrought-iron, and steel, each class having numerous varieties, and each variety differing in

its capability of withstanding the various strains to which machinery, or iron structure, may be subjected, and its capability of being annealed or tempered to any degree of hardness, according to the amount of foreign matter, principally carbon, which it may contain, or the molecular condition assumed at ordinary temperatures. Cast-iron, which is the first production from the ore, is found containing from 90 to 95 per cent. of iron, with from four to six, or an average of five per cent. of carbon, part being chemically combined, and part as free carbon, in the form of graphite, and is known as Nos. 1, 2, 3, or 4 pig-iron, according to the fracture it shews when broken, No. 1 pig having more free and less combined carbon than the higher numbers. The other impurities, silicon, sulphur, phosphorus, etc., weaken the iron and deteriorate its value. Wrought-iron is made from pig iron by burning of the carbon and silicon, the ordinary method being by boiling it in a reverberatory furnace in small quantities. This process is known as puddling. The other impurities, consisting chiefly of slag, are taken out in the process of shingling or hammering, and afterwards the iron is rolled into bars, broken up and built into piles, re-heated, hammered, and rolled, and this repeated several times making the brands "best," "best best," etc., according to the purposes for which the iron is used. (The author here showed fractured and bent samples to illustrate the different brands.) The iron which ought to be selected for a chain is that combining the greatest hardness with the greatest strength, that is, hardness to resist wear, with as much fibrous nature as will give the maximum strength to resist the twists and shocks a chain is subjected to. Mild steel such as is made by the Siemens-Martin process, and which can be as readily welded as malleable iron, may yet have a great future for chain making. The difference between mild steel and puddled iron is very little, chemically. Mild steel does not harden when heated and plunged into cold water, but it can be fused at a much lower temperature than malleable iron, hence steel castings are taking the place of forgings. Both wrought-iron and mild steel contain about ·2 per cent. of carbon, while steels containing from ·3 to 1·5 per cent. of carbon get gradually more difficult to weld, and take a

hard temper when heated and suddenly cooled as the proportion of carbon increases. The relations of carbon and iron stand thus —with two per cent. upwards, cast-iron; with from ·2 to 1·5 per cent., the various grades of steel; and with from ·1 to ·25 per cent., the various grades of malleable or wrought-iron. If a chain or piece of iron work be subjected to various strains and jerks, or a fixed rod or tie-bar exposed to the expansions and contractions due to variations in temperature, though no outward signs of wear are seen, the strength becomes gradually diminished till it breaks. This happens even if it be made of the best selected iron for the purpose. On looking at the fractured piece it is found that however fibrous the iron was when new, it has now a cross-grain resembling cast-iron, and under the hammer it will break more like cast than malleable iron. An analysis shews that chemically it has not changed, and if heated in the fire it will be found that its welding property has not changed. It may, therefore, be concluded that the change is not only mechanical, but that a permanent re-arrangement of the molecules has taken place, something like that which takes place in tempering steel. Now, in order to soften hard steel it is necessary to bring it to a dark red heat and let it cool slowly, and if it has to be manipulated with tools, very slowly, heaping hot ashes over it, or putting it in quick lime, etc. The theory of the process of annealing has never yet, so far as the author is aware, been explained. The fact was said to have been discovered by the breaking of railway axles when the crystalline nature of the fracture appeared so different from the original fracture that it led to inquiry, resulting in the discovery that the annealing of wrought-iron at regular intervals restored it to its former nature. The author is not aware if the process has been applied to railway axles, but he knows that it has been applied with very beneficial results to chains, hooks for cranes, sling chains, etc., for lifting heavy loads. In many cases these are annealed once and sometimes twice a year, all depending on the nature of the work which they are required to do. (Here, two links were exhibited taken from a chain that had given way, one of the links when being struck upon its longest diameter broke in four pieces, another of the links after having been annealed stood

hammering till it was flattened the opposite way before breaking.) As to the theory of what takes place during annealing, the author has tried to reason it out, based on the molecular theory and the motion theory of heat. Granting then that good iron has been mechanically changed in its structure but still possesses all its original properties, there is a tendency to re-assume the original arrangement of the molecules, and when heat, which is not only motion of the molecules, but that motion which liberates them and sends them further apart, they are then free to assume their original arrangement at that particular temperature, and being so slowly cooled that the repelling force of the heat is simultaneously overcome by the attraction of cohesion, they settle into the same state at ordinary temperatures as they originally possessed. The following are a few practical hints on the treatment of iron work. Where weight is not an objection, the lower qualities of iron may be used if made excessively strong, but if difficult to get at for annealing or repairs such as the ends of pump rods, etc., the best iron only should be used. If a break-down occurs, which can be repaired by welding, the whole piece should be annealed. In the case of long chains for haulage purposes, samples of the iron should be demanded before purchasing, and the best quality chosen, and as light a chain as will do the work safely should be employed, as it will be much easier on the roads, wheels, and axles, than a heavier one. When a chain has been subjected to a considerable amount of work it would be well to test a link here and there with a hammer. If it does not appear to bend, either bend or break it by increasing the strength of the blows, and should it break with a crystalline fracture it would be well to prepare for annealing the whole chain as soon as possible, which should be done in the following manner :—The articles to be annealed are placed in a pile of wood and shavings in such a way that the heat will get as near as possible equal all round. After lighting, wood must be piled on till a dark red heat is obtained, then the fire should be allowed gradually to die out, keeping the articles well covered with the hot ashes until they can be touched with the hand. This experiment any one may try with a piece of old chain, breaking a link before and another after the process, and prove the result for himself.

The PRESIDENT said this was a very interesting as well as a very important communication. It seemed to him such a very important thing that if the results were as Mr Johnstone stated, —and he believed they were—they should be brought out. He should like very much to know if any of the gentlemen had any experience, and above all how long was it since the process was first adopted. He had heard the late Mr Dunn talk of it as being done in some of the English collieries in 1842, and if he mistook not he mentioned it in his book published in 1846. He asked Mr Drinnan if annealing was known in the Yorkshire collieries.

Mr DRINNAN—I never heard of it before hearing it spoken of here.

Mr MUNGALL thought this was a matter with which they were all familiar in a pretty rough way. They all knew that the link of a chain often broke unexpectedly, they took it up and looked at it and found it was the same as the one shewn, and they said it was a bit of bad iron and the man who supplied it had supplied an inferior article. He did not know if they were prepared to discuss this paper just now, but he thought they were all prepared at very little trouble to take a piece of old chain and experiment on it, and he would venture to suggest that a number of members might do so and communicate the result of their experiments to the Institute. There was just one other point: he did not know whether it would be worth while to have a few links of an old chain tested before it was annealed at the testing machine. Mr Johnstone would inform them if that was a proper test.

Mr JOHNSTONE said such a test would be very good, but not so good as a shock. The iron in that state was stronger for a straight pull—the grains were more closed, but with a jerk it took the nature of cast-iron.

Mr MUNGALL—What I meant was two links tested, one not annealed, and one that had been annealed.

Mr JOHNSTONE—You mean together?

Mr MUNGALL—No; the one tested, and the strain found.

Mr JOHNSTONE—The softer link would draw more and then break.

Mr MUNGALL—What I meant was—take four links, subject two of them to say any rude test, such as that of a hammer;

subject the other two—one of them annealed and the other not annealed—to the testing machine. I do not know whether this has been done, but it occurs to me that it should be to ascertain the tensile strain.

Mr DEWAR said that he heard of annealing at last meeting. They were travelling very much with their chains direct, so he took one which was thrown off for being old. It was a three-quarter chain. He cut a link in two, cutting it very easily through. He then broke one of the pieces hammering it through like cast-iron. They annealed the other, and it bent up when struck. That showed the difference between the annealed part and the part not annealed.

Mr ARNOTT directed attention to the specimens he had placed on the table as showing this.

Mr MUNGALL—My suggestion has apparently been anticipated.

The PRESIDENT said it was a very important suggestion, and one which it might be well for the Council to consider whether a committee should not be appointed to carry out.

MR HOGG'S PAPER.

The PRESIDENT invited discussion on Mr Hogg's paper on "Longwall."

Mr BARROWMAN—In the opening of his paper Mr Hogg alludes to pillars round the shaft and opposite main roads. Bottom pillars may in some cases be dispensed with, and the whole coal taken out, especially if the seam be at a considerable depth. I do not think it is desirable to have pillars alongside main roads; they prevent the strata from settling down evenly, and the road needs in consequence frequent repair; and the coal afterwards got from the pillars, if got at all, will be very small. It may be expedient to leave such pillars where a rapidly increasing output is wanted, as walls can be more quickly opened out in that way; and perhaps also in cases where gas is abundant and a strong current of air is required at the face, coal being closer than new stowing.

Pillars are also sometimes left along the levels in highly inclined workings to act as a support for the buildings and stowing of the roads branched to the rise. In some cases this is not found to be necessary in practice, and it is injurious to the main road in workings of moderate inclination. I am of opinion that the main road should not be next the solid coal even with several yards of stowing between, but that another road be driven parallel to the main road and between it and the solid. This road may be cut off from time to time by a branch from the main road, and if it be going level course it may be used as a water level if necessary afterwards. If this lower road be driven the main level is saved the disturbance that follows the working away of the dip coal. A straight road is, as Mr Hogg points out, the safest and the cheapest. The matter of making straight roads deserves, I think, more attention than it gets. Much expense, trouble, and delay are caused in straightening crooked roads or making new ones for self-acting inclines or other modes of haulage, which a little forethought and due exercise of discipline might have been prevented.

We have been so accustomed to associate Longwall working with thin seams of coal that there may be a danger of losing sight of the practicability and profit of working thick seams also by Longwall. I do not know that the latter has been tried to the extent it might have been with advantage. At all events it would be interesting and valuable if a comparison were made and brought before the Institute of the relative merits of working the same seam by Longwall and Stoop-and-room. Difference of opinion on that point was expressed at last meeting, and it is worth being looked into and, if possible, cleared up. So long as dross is of so much less value than coal the working of a seam so as to produce the greatest possible quantity of round coal is clearly of great consequence, and what is aimed at is to carry forward the faces of the coal at such a rate, in such a form, and with such under and side cutting and after building as shall allow the weight of the upper strata to act upon the coal in the way best for its down bringing and with the least breakage. I think all are agreed that Longwall working should be continuous if it is to be carried on to best effect. A room in a Stoop-and-room

working may stand for a day without injury, but a Longwall face hardly. The form of the faces (whether in a continuous line or working the one in advance of the other) appears to me to be a matter worth looking at. The extra cutting along the solid rib side and the crushing of the outside corner by the weight are apt to prejudice us against working with the faces the one before the other. It would appear, however, that this form of faces has been tried with advantage where with a good roof the coal was liable to be too much crushed. The line of subsidence in such a case is parallel to the general line of the faces, and the weight is thrown upon the outside corners, so relieving the wall along the greater part of its length.

The discussion was then adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 11th MAY, 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

James S. Dixon, Esq., Vice-President, in the Chair.

Nearly forty members were present at the meeting.

The Secretary read the minutes of the Annual Meeting, and the Council Meetings; they were approved of and signed by the Chairman.

The following gentlemen were balloted for and admitted as Ordinary Members:—

JOHN HYSLOP, Manager, Heathery Knowe Colliery, Bargeddie.
JAMES S. JENKINS, 33 Renfield Street, Glasgow.
HENRY W. LEWIN, Mining Engineer, Drumpellier, Coatbridge.
WILLIAM LUKE, Colliery Agent, Prestongrange.
JAMES MAXWELL, Burnbank, Hamilton.

The following were nominated for election at next meeting:—

JAMES BEVERIDGE, Colliery Manager, Loanhead, Edinburgh.
FRANCIS DANKS, Oversman, Albyn Cottages, Broxburn.
ALEXANDER KENNEDY, Colliery Manager, Broxburn.
WALTER M'FARLANE, Colliery Manager, 12 Whitefield Road, Govan.
ARCHIBALD RUSSELL, Junior, Coalmaster, Roslin, Bothwell.
JOHN R. WILLIAMSON, Mining Engineer, 12 St Andrew Square, Edinburgh.

DISCUSSION ON MR HOGG'S PAPER ON DETAILS OF LONG-WALL WORKINGS.

The CHAIRMAN, in introducing the discussion on this paper, said he was not present himself at last meeting, and he must plead guilty to not having studied the paper; but there were the points thrown out by Mr Barrowman as to the bottom pillars. Had any one experience of places where they had not left these, and what had been the result? This was a paper for practical men if they would just state their experiences.

Mr GRANT, in answer to the Chairman, said they had had some difficulty on this account at Bothwell Park. He did not think they would be better without a pillar at the bottom; he would rather have plenty of coal round the bottom.

Mr DRINNAN rose to call attention to some remarks made by Mr Barrowman at last meeting with reference to pillars alongside main roads. He had had some experience of that kind of work, viz., where pillars were left alongside main roads with the coal varying from 4 to 5 feet in thickness and the workings sometimes about 7 feet in thickness. The pillars alongside the main roads were from 25 to 30 yards to the rise and 30 yards in the level, and he must say they had very little if any trouble with the roof at all. He thought it would be desirable to have Mr Barrowman to state what were the conditions of roof and floor, and what was the size of pillars where he found it was a bad thing to have them, because he thought the question would have to be determined by the roof and floor and size of pillars. It might be found to be a bad thing; it was not so in his experience where the pillars were left large. With regard to the suggestion that there should be a lower road between the main road and the solid coal, he would like Mr Barrowman to state what distance he would have between these roads, and what distance between the lower road and the solid rib of coal, because they all knew a very considerable subsidence would take place where there was some thickness of coal, and his experience, from all he had seen and read, was that a main road placed in the position Mr Barrowman desired those to be would require to be brushed two,

perhaps three, times before it could be said to be a finished road. It might be, however, that he would have them at such a distance as would make this less likely, but he (the speaker) could conceive of no possible conditions whereby he would avoid such a subsidence and prevent the brushing. Mr Barrowman proposed, he understood, to cut off the low road by bringing the branch up on to the main road. That might answer very well where the seam was actually level, but the seams very generally were found to lie with a dip and rise, and putters would be required to bring the coal up. He did not think such a branch would be serviceable as a water course, because, practically, it would be found that that low road would fall very badly, and unless constantly used as a drawing road the probability was it would be so silted up that it would not be available.

Mr BARROWMAN said that the remarks he made at last meeting had no special reference to any particular seam or any particular inclination of a seam, but were made up from observations of a large number of workings. He found it was not usual to leave pillars alongside main roads, and he had no doubt that practice had proved to managers in this district generally that pillars could quite well and profitably be dispensed with. As to the width that Mr Drinnan would like the lower road to be from the main level, he could not say he was prepared to specify a particular distance. The depth of the pit and other circumstances had to be taken into consideration; and, in suggesting that the lower road might be used as a water-course, what was particularly in his mind was what he had frequently seen, viz., the main level being flooded with the water that should have gone along the water level at its low side, had it not been choked up. It was surely preferable to have the water going along the low road, rather than along the drawing level, where it might be an annoyance both to man and beast.

Mr ROBSON had not intended to take part in the discussion of this paper, but the remarks of Mr Drinnan had suggested to him that he might say a word or two. He knew several instances where there had been pillars left along the main road of long-wall workings, and as a rule he found it was considered bad practice. As to the other point,—the low level—he entirely agreed with

Mr Barrowman that it would be a good thing in many cases to have a lower road, which probably ought to be kept open as a water way. He thought that it would not only drain the horse or other haulage road and make it easier on haulage, but the fact of there being a road on the low side of the main road made the main road stand better because it would be further from the edge of the long-wall workings.

Mr WILSON said there was another reason why it was a benefit to have such roads. If they had any workings to the dip, and the main road was near, it would be much damaged by the fresh crush. Mr Drinnan alluded to the brushing of the main road. The best method is to brush the road in the usual way, and re-brush it fifty fathoms behind the working face. That was the experience he had had where the workings were very extensive. There never was any trouble with the main roads afterwards.

The CHAIRMAN, as regards the point mentioned by Mr Drinnan, said his own idea was that the whole thing depended on the size of the stoops. If they were left large enough to equal the solid coal, there was no doubt they would protect the road, but as a general practice he thought that stoops in long-wall workings were a mistake. He agreed with Mr Barrowman, and he thought it was the usual practice to carry in a low level and occasionally to put down a short spur road from the main level. As Mr Barrowman said, it acted as a water level, and it took the weight off the top level; and, as Mr Wilson said, in the event of a future working it saved the crush from coming on to the main level. He had seen many levels destroyed from that cause. He understood Mr Barrowman had some notes on a Derbyshire long-wall working, and he invited him to read them to the meeting.

Mr BARROWMAN said since last meeting of the Institute, Mr Hastie and he had been at Shipley Colliery to examine into the mode of getting coal by the use of caustic lime; and it occurred to them that, seeing the subject of long-wall working was under consideration, they might say something as regards a mode of long-wall working which came under their notice. Mr Barrowman then read as follows:—

The seams of coal which appear to be most extensively worked in the Derby and Nottingham districts are the Top Hard seam, which lies nearly 250 fathoms under the magnesian limestone at the base of the Permian rocks, and the Deep Hard seam, fully 100 fathoms lower than the Top Hard.

We shall have occasion a month hence, when submitting our report on the method of getting coal by the use of caustic lime, to describe the mode of working the Deep Hard seam at Shipley Colliery, and shall confine our remarks meantime to a description of the details of the mode of working the Top Hard seam at a colliery near Nottingham, where the system is carried out in a very complete manner.

The pits, which are tubbed, are 227 fathoms in depth. The strata are little disturbed by slips and lie at a very moderate inclination, and the workings are perfectly dry. The mode of working is long-wall, the walls or stalls being from 25 to 30 yards in length, and the coal 3 feet 5 inches in thickness. The following is a section of the working.

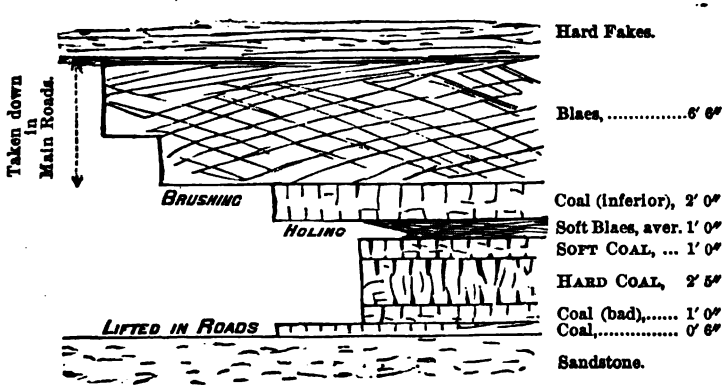

Fig. No. 1.

The holing is in the blaes on the top of the good coal, and is made from 1 to 3 feet in depth, according to the manner in which the weight is affecting the seam, and sprags are usually put up in

the holing 6 feet apart. The stalls we examined were working almost on "end" of the coal, and we were informed that no blasting is required, but the coal has occasionally to be wedged at the bottom; usually, however, the pick or crowbar is sufficient as a means of getting the coal off the face in large pieces. Where the stalls work on the "plane" of the coal it is more crushed.

The rubbish from the stalls and brushing is sufficient to pack the waste or gob, and a pack wall is carried along the whole length of the stall with a built front every 4 feet or so, as shewn on the sketch (Fig. 2). Two rows of props of 5 inch wood are put up between the pack wall and the coal, those in the one row being close to the pack wall, and, by a rule of the colliery, not more than 6 feet apart, and those in the other row being close to the coal, and also not more than 6 feet apart, the distance between the two rows being sufficient for the passage of the tubs which are led on rails along the stall. The front of the pack wall is rarely more than 6 feet from the coal. A few cast-iron props are used, generally 4 in each road head. A rule of the district requires that a number of spare props be always at hand, and these lie at the roadside a few yards from the face.

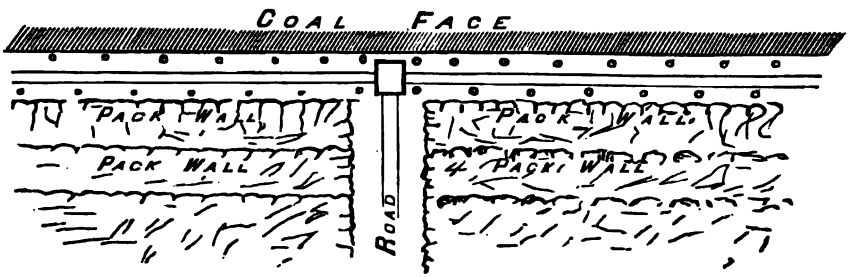

FIG. No. 2.

The coal having been holed along the whole length of the stall, and the rails between the two rows of props lifted, a cut is made into the coal at the gate end or road head, about 4 feet or so of the coal removed, and the plate shifted forward. The taking down of the coal along the face, both to right and left, is then

proceeded with, the rails being laid and the tubs being taken further along as the coal is extracted. Simultaneously with the taking down of this strip of coal, a new pack wall is being built (as at X on sketch—fig. 3), the props *a* at the back of this new pack wall having been taken out and put up at *b*, close to the new face of coal.

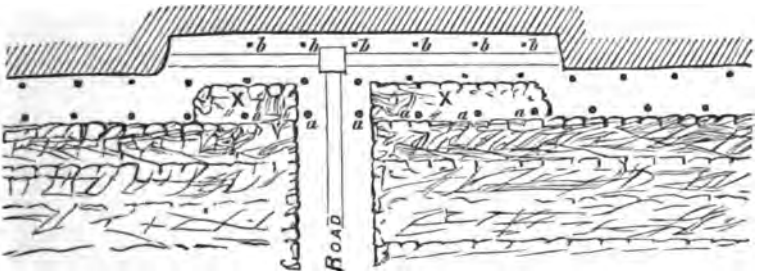

FIG. NO. 3.

The dross or slack made in the working, and which may be a tenth of the coal worked, is not put out, but is thrown into the gob. Four men are employed in each stall, and we were informed that the output per man is about 4 tons a day. These men also put up the props, and take down the inferior coal.

The branch roads are cut off by a new cross road every 5 chains or so, and the top coal is brushed in these. In the main roads part of the blaes is taken down, 100 yards back from the face, and when the strata have settled, the whole of the blaes is taken down, the fakes forming the permanent roof, after which almost no timbering is required. The brushing is done by means of the picks.

We had also an opportunity of examining a working in the Main or Deep Soft seam of coal, which lies about 8 fathoms above the Deep Hard seam. The mode of working is similar to that at Langley Mill Colliery, described in a recent report on propping by a deputation from this Institute.

The pits are 110 fathoms in depth to this seam, which is quite free from water. The inclination of the strata is very moderate,

and the tubs are taken along the walls, which are 60 yards in length, the coal being worked on "end." The seam is 3ft. 10in. in thickness, and the following is a section of the working :—

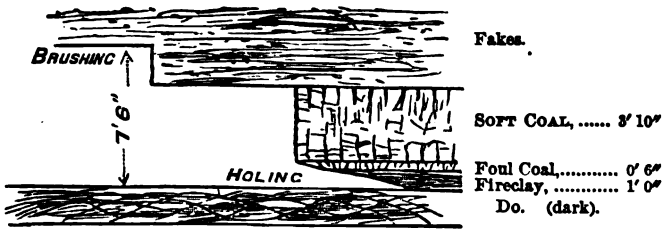

FIG. No. 4.

The foul coal and fire-clay under the seam are holed to a depth of 5 or 6 feet, and sprags are put up not more than 6 feet apart. The rubbish turned over is not sufficient to fill the gob, and, instead of a close pack or stowing, there are pack walls about 6 feet thick, and 9 feet apart, carried forward at right angles to the line of coal face, as shewn on sketch—fig. No. 5.

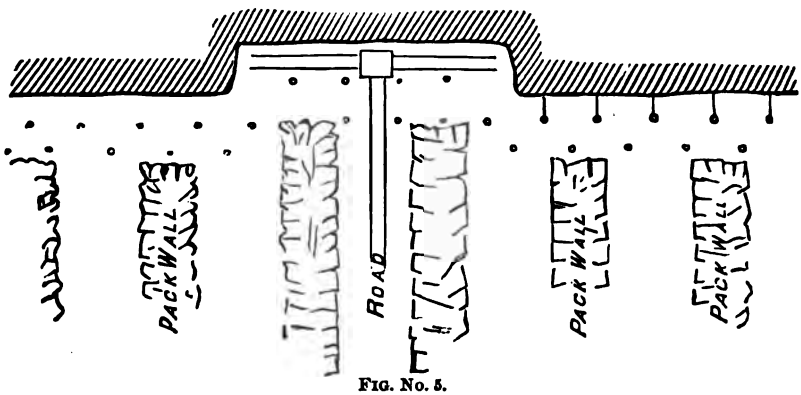

FIG. No. 5.

Along the whole stall between the end of these packs and the coal there are two, sometimes three, rows of props, of 6 to 8in. wood, 6 feet apart in the row, the two rows being about three feet from each other. The back props are taken out and shifted forward

next the coal, as the building of the packs advances. The tubs are taken along the face between the inner row of props and the coal. Where the roof is tender, straps composed of old rails are put up between the coal and the props in the nearest row, the inner end resting on the top of the coal. Neither blasting nor wedging is required to bring down the coal, as it falls when the sprags are drawn. The brushing is done by blasting.

The CHAIRMAN invited discussion on this very instructive description of long-wall working.

Mr DRINNAN, with regard to the remarks made by some gentlemen as to what he said at the commencement of the discussion, thought that members would see that all those who had taken up the subject had failed to give the information he thought it was desirable to elicit, viz., the size of the pillars and the conditions of the roof and floor, because, as he endeavoured to impress on the minds of the members, it was these conditions that he thought would always determine what was likely to be best. Several members had spoken as to the roof and pillars and as to having the main road near to the solid coal, and to the main road suffering. He had seen that done not merely with one particular road but long stretches of half a mile where it had been working up from the dip to within 25 and 30 yards, and no injurious results followed. That was the practice where he had been.

Mr R. T. MOORE thought with regard to Mr Drinnan's experience in leaving in pillars alongside the main roads, the effect on the roof must be very much the same as that of stooping in stoop-and-room workings, and there were frequently cases where stooping was carried on to within a few yards of the main road without affecting it. He knew of a case where a corner of the stooping of one colliery was not more than twenty feet from the main road of another colliery, and the main road was not affected. In another, a considerable area of stooping was carried on within two stoops of 30 yards each from the main road, and in the space between the main road and the stooping the roof was not at all injured. It, of course, as Mr Drinnan said, depended upon the nature of the roof and the pavement.

Mr ROBSON said that it might be quite true that in some

instances there was no particular injury done in the first working, but with only a pillar of coal, say 20 or 30 yards on each side, he thought there would be too little coal to work at in the back-coming. The weight on each side would come over the pillars when once those stoops were attempted to be taken out. It would certainly result in a great loss of coal.

Mr DRINNAN would like to guard against being considered as laying down any particular dogma as to the mode of working. He merely wished to have information.

The CHAIRMAN thought that Mr Hogg's paper was one on which a great deal more ought to have been said. It was more a paper for practical men than for people who, although going down pits frequently, had not the same opportunity of forming an opinion. With regard to Mr Drinnan's stoops, he said before, and still gave it as his opinion, that it would be a great mistake to work in that way. He did not see how they were to air those pillars in coming back, and he was certain it would be a very dangerous operation. He would like the opinion of members as to what breadth of stoops ought to be near main roads, for he thought they often ran risks in taking them out too near.

The SECRETARY said he understood Mr Drinnan had given them the results of his experience at a very large colliery in England, where stoops were left alongside the main roads. Perhaps Mr Drinnan would explain how he brought them back and what it cost to work them compared with the long-wall workings. He (Mr Gilchrist) remembered on one occasion seeing the workings on which Mr Drinnan was engaged; he was very well pleased with them, and thought they were carried out in a very economical way. The main roads were certainly in good condition.

Mr DRINNAN—There was no stooping done when I was there.

The SECRETARY—What breadth of coal was there to bring back?

Mr DRINNAN—Twenty-five to thirty yards to the rise, and thirty along the side of the level. There was a slit at every thirty yards, and a main road at every sixty.

Mr HASTIE said the long-wall described by Mr Barrowman was one of the most perfect he had seen. That was the reason why Mr Barrowman and he thought it worth while to have a few

words on it seeing that a discussion on the subject was going on here. Every road was as straight as a line, and every building was packed closely, and the weight was so regularly on the face as to be scarcely noticeable. The coal was easily got and there was little dross. The colliery had been going for six years, with an output of 1500 tons a day, and there had not been a single fatal accident, although the workings were two miles in. He himself had learned a lesson, which he thought ought to be conveyed to the Institute.

Mr ANDERSON for one was very glad to hear the description if for no other purpose than just to show them that they ought perhaps to study a little more system in their workings in Scotland than they did. One thing he admired in it was the great regularity with which the face was carried forward and the way the props were set and buildings put up—all alongside the roads and in the working face. He had no doubt if they could carry out the same exactness in working, and the same perfect discipline, possibly they would have better results here too. He dared say every one in the habit of going down a pit and seeing a long-wall working was annoyed to see how the buildings were carried forward with outs and ins. One thing, it was much easier to draw a line and lay down plans than to carry them out. As to the system of putting in props with sharp points, he had tried that many years ago where there was a soft roof and a hard pavement, and found it exceedingly beneficial. He had no doubt it was a good system. He had seen recently stoops left alongside a main road in both long-wall working and stoop-and-room, and the stoops worked up within 30 yards of the one side and 40 yards of the other. He thought it was quite a good protection for a road. It made a good road while they were going in, but he did not think it was a very good thing for getting the coal out as they were coming back, because in the 40 yards' stoop they had generally to put a place through, and the weight on both sides met in the centre, and if the pavement had a tendency to heave,—and in this particular instance it had, as it consisted of three feet of foul coal—it was sure to do so. Therefore, although it might be good for going in, he did not know that he was prepared to advocate it on

the whole, keeping in view the working back as well as going in. But for long-wall working he would incline—as he heard just the purport of what Mr Barrowman's remarks had been—to have a road alongside the main road between it and the solid, seeing it was a pretty good protection either when working with another drift through the top or across the level. It prevented the main road from being injured, because the strata above were still permitted to settle between the buildings of the main road and the other to the dip or alongside of it. Long ago, in the first long-wall working he remembered seeing, the roadsides were built with freestone which was taken down the pit. It was about 5 feet high.

Mr DRINNAN welcomed Mr Anderson's remarks as a most practicable and valuable contribution to the discussion.

Mr DUNDAS SIMPSON said that, with regard to the question at issue, as far as his experience went with reference to long-wall workings, he was entirely opposed to Mr Drinnan's method of leaving pillars along the road sides. He had in the past done so, and he had found in his experience that he had committed an error by doing so. Once the pits were sunk to the seams intended, and with the idea of working long-wall, he would, instead of leaving stoops, take all out together and leave nothing in until they came to their destination; and the experience he had had led him still further to the opinion that no stoops should be left in at the pit bottom or along the road sides. He found leaving no stoops was the most practical way, and at the present time they were building the road sides. There were stoops along the horse road, and these were about 30 fathoms square. He found that with those stoops standing by the road side it was a matter of impossibility to keep the roads properly; and if stoops were left he should like some one to define what size they ought to be and what sort of roof and pavement. Mr Drinnan had asked the question, but it had never been answered. He was not disposed to leave any coal—any pillars of any kind—in working long-wall.

Mr DRINNAN answered that the major portion of the roof in the working he referred to was what they called "bind,"—in some parts a hard "bind," in other parts very much more

"brittle," very brittle indeed. The roof above the "gob" was "fakey" blaes.

Mr ROBSON—Blue "bind" is similar to the Scotch "calmy blaes," like the roof of the Ell coal in most of the Hamilton district.

Mr DRINNAN, in answer to the Chairman, said the depth of the seam was 160 yards.

The CHAIRMAN asked if any gentleman could corroborate Mr Drinnan's opinion.

Mr LAW thought Mr Drinnan would get very few people to agree with him.

Mr DRINNAN repeated that he did not wish to lay down any dogma.

Mr LAW said the roof mentioned by Mr Drinnan was different from any he had heard of.

Mr DRINNAN—It is different from any roof I ever saw in Scotland.

Mr RITCHIE asked regarding the two stoops, if all the coal was taken out in each side? He urged that only half of the coal would be of use for protecting the road. There would be so much drawn over, that there would be only 15 yards for protection in place of 30.

The CHAIRMAN—You mean half of the pillar would give no support at all?

Mr RITCHIE—Yes.

Mr SHARP thought it all depended on the roof and the pavement. He knew a colliery where he used to work as a miner. There was a hard pavement and a soft roof. Every piece of coal was taken out after leaving the bottom stoop. They thought to try this and did so; and the road, so far as he was aware, had been the best part of it. Those last six or eight years the stoops had been left in. Therefore, he thought it all depended on what kind of roof and what kind of pavement there was.

Mr BARROWMAN, with regard to leaving pillars along main roads, said he asked this very question at the manager at the colliery, the working of which he described. It was a system in practice in some Derbyshire collieries to leave such pillars. That was the reason why he asked him,—seeing the workings were

extensive and he had good reason to know the *pros* and *cons* of the question ; and he told him most distinctly it was preferable to take out all the coal, and as a matter of fact the main roads, after being brushed up of the "fakes," were almost entirely free of timber.

Mr DALZELL said, perhaps some of those who had spoken might explain whether, in those cases where coal was left for the purpose of maintaining a good road, it was ever in practice taken out. From what he could gather from any of the speakers it did not seem to be intended to be taken out. He would like to know if it were.

The CHAIRMAN—Mr Drinnan says he did not see it taken out.

Mr SHARP said in the case he has referred to, the workings were still going on busily in the inside, and what might be done he did not know, but he had an impression that there was no intention of taking the pillars out. Mr Barrowman's sketch of the colliery he visited in Derbyshire just brought to his mind another experience he had had where the works were in a thick seam, the gradient being nothing less than 1 in 3 or 1 in 4. There was considerable difficulty in keeping long-wall roads there, and it was only done after the very system of packing and setting of props regularly at intervals of six feet had been adopted. They could never keep their main roads until they put in every second building entirely of wood and the top part of every second building in the side roads. The great success of that was the minuteness and regularity with which the whole thing was carried out.

Mr DRINNAN, though he did not observe the stoops being worked, did not see what difficulty there could be in doing so. The main difficulty he could see would be in ventilating them. He did not see that that should offer any obstacle either, because their air might be taken in the lower level, and returned along the main road when going round the stoops in process of being worked. In their report it was described how they worked the stoops. At Barnsley they were working them by keeping one somewhat in advance of the other. He did not see that there could be any great difficulty in doing that.

Mr DUNDAS SIMPSON said that when he was in the service of

the Uphall Oil Company, there was not a single foot of the roads which was not built with wood, and singular to say, he never had more difficulty in keeping roads in a pit.

Mr SHARP—That was just where the mistake was made. He knew where the same thing was tried, and it was found that when the buildings were built too tight and the subsidence not allowed to come its proper distance a difficulty arose.

The CHAIRMAN said it seemed to be a subject on which there was a great deal to say, and he adjourned the discussion till next meeting. He thought they ought to encourage every member to act as Mr Barrowman had done in bringing descriptions of systems of working before them. (Applause.)

Mr BARROWMAN said that the contribution was not by him individually, but by Mr Hastie and him.

MR JOHNSTONE'S PAPER.

THE CHAIRMAN, in introducing the discussion on Mr Johnstone's paper, said it put him in mind of the story of Aladdin's Lamp. It was getting new chains for old ones. He thought, in reference to the change of the molecular character of the iron through successive shocks, that it was possibly a magnetic one. If they took a bar of iron and struck the end on the ground, it turned into a magnet. That showed a change had taken place in the iron, and if they repeated the striking continually and changed the end of the bar struck the one end would be the north pole and the other the south pole alternately. He had no doubt this would change its character, and probably the annealing did away with this, and made the iron as good as before. It was a very useful paper.

Mr JOHNSTONE, as regards the chains being magnetic, said they did not show this in attracting matter, but they knew that very often a whole ship became magnetic from the rivetting. Whatever the cause might be, the molecular structure of

substances was one of those things about which they were very much in the dark, and as to how they got No. 1 and No. 3 iron out of the same blast was one of the things they could not explain. It was a mechanical change, not chemical, and the change taking place in iron with repeated shocks was a mechanical change of the molecular structure, how or why was beyond their knowledge. It was like tempering a chisel. The whole change took place by simply heating and cooling. It was useful to know, and about pits it might save many a costly accident if chains, hooks, and attachments were occasionally annealed, especially before the wintry weather set in.

Mr DRINNAN said the subject of annealing, as he before explained, was a somewhat new one to him, but since he heard Mr Johnstone's paper—which was a most important one—he had been thinking on the possible cause or causes which led to the re-arrangement of the molecules in annealing, and, re-membering that fractured iron which he had seen had the fibrous structure best defined in the centre, he had wondered whether the process might not be explainable by supposing that the outside surface of the iron cooling and contracting while the interior molecules were still in a state of greater mobility, because of their greater heat, would account for its toothlike structure.

Mr JOHNSTONE replied that in cooling large castings, what Mr Drinnan mentioned took place; but unless cooled very fast iron was so good a conductor that the cooling was almost simultaneous. In making chains, he had had an idea that there would be much benefit in having fibrous iron in the centre and hard iron in the outside. They would then have a soft fibre in the centre and a hard skin outside.

The CHAIRMAN begged to move a hearty vote of thanks to Mr Johnstone for his valuable paper. It was a very useful one, and he hoped members would carry out his proposals.

REPORT OF SAFETY LAMP COMMITTEE.

Mr BISHOP read as follows:—

LAST Autumn, this Institute appointed six of their number to examine and report upon Dr. Heinzerling's Safety Lamp. A meeting was thereafter held at Cadzow Colliery, where the lamp was tested in fire damp. The following is the report:—

DR. HEINZERLING'S PATENT LAMP.

The lamp consists of 4 principal parts:—1st. A bottom 3 inches diameter containing the oil reservoir, and a space above it three-quarters of an inch deep filled with glass wool. The air for combustion comes through a strip of gauze forming the side of this, then filters through the wool and passes to the burner through a second layer of gauze. The burner is one suitable for mineral oil, with wick $\frac{3}{8}$ of an inch broad, and fitted with small glass chimney 5 inches high, 1 inch in diameter at the top, and 2 inches diameter at the widest part. 2d. A thick Clanny glass, $5\frac{3}{8}$ inches high by $2\frac{3}{4}$ inches diameter encloses the burner and chimney. 3d. On the top of this glass a second filtering chamber is placed containing about 1 inch in depth of glass wool. The products of combustion pass through a gauze, forming the bottom of the chamber, then filter through the glass wool and pass into the atmosphere through the top and sides of the gauze. 4th. An iron case to hold the lamp, which is the only means employed to keep the other parts together. This case opens with a hinge and is locked with a hasp and padlock. The total height of the lamp is about $9\frac{1}{2}$ inches, and the weight is $3\frac{1}{4}$ lbs.

The following objections were taken to the lamp on its production for trial at Cadzow Colliery, 18th August, 1881:—

1. Number of parts and weakness of construction likely to cause a larger outlay of repairs.

2. Larger exposure of glass, which, being that of a single cylinder, leaves, if broken, the flame to the outside atmosphere.

3. Great heat of the top of the glass cylinder after the burning has continued for some time, so that if then placed under water dripping from the roof the glass will crack. This took place not on a first trial but on a second.

4. It does not indicate the presence of fire-damp in small quantities so readily as others.

The 2d and 3d objections were deemed decisive against its use as a safety lamp in ordinary working.

The advantages of the lamp over the Davy and the Williamson lamp were that the light given was stronger, and the roof was much better shewn by it. When the Williamson lamp was placed on the floor of a place 5½ feet high place, the shadow hid a portion of the roof above it 7 feet diameter, while the whole roof could be seen by Dr. Heinzerling's lamp, only darkening a little a space above it less than 3 feet diameter. On placing the two lamps at such distances in a long mine that the flames appeared to be of the same size and calculating from these distances, Dr. Heinzerling's lamp was found to give from 7 to 8 times more light than Williamson's.

The committee thereafter thought it might be of advantage to the members of the Institute to examine some of the safety lamps in general use in the district. At their suggestion other eight members were added to their number.

Various meetings were held at Earnock and Cadzow Collieries, and at Hamilton Gas Works; and, after mature consideration, it was decided to confine the investigations solely to the cost of lamps, their upkeep, repairs, and lighting powers, and not go into the question of safety at all, seeing that the Royal Commission on Accidents in Mines were making elaborate experiments in that direction.

The following are particulars as to safety lamps at various collieries :—

BLANTYRE COLLIERY.

Davy Lamps.—Average life of gauze, 6 months; first cost of lamp, 4s; length of gauze, 6 inches × 1½ inches diameter; weight when trimmed, 2⅛ lbs.

BENT COLLIERY.

Scotch Gauze Lamps.—Large size, 11 inches × 3¼ inches—cost of oil per day of 10 hours, 1·08d; small size, 9½ inches × 3 inches—cost of oil per day of 10 hours, ·99d; repairs (on 70 lamps), 6s 9d per year per lamp.

ALLANSHAW COLLIERY.

Scotch Gauze Lamps.—First cost of lamp, 3s 9d; size, 10 inches × 3½ inches diameter, burning flat wick; cost of lighting, about 1d per day, or rather less when solid paraffin wax is burned; repairs (on 70 lamps), 6s 6½d per year per lamp.

BACKMUIR COLLIERY.

Mueseler Protector Lamps—Burning naphtha—71 lamps in use.

Cost of oil per year (300 days) per lamp, ...	£0	7	4½
Repairs Do., do., ...	0	0	4½
Gauzes and Glasses, do., ...	0	0	2¾
Lamp trimming, do., ...	0	9	3½
Total cost, ...	0	17	3¼

CADZOW COLLIERY.

Williamson's Lamp.—Burning colza oil—Cost of upkeep, inside glasses, 2s; outside glasses, 5d; gauzes, 3d; caps, 3d; total, 2s 11d; total cost of trimming, wages, and repairs, 1d per day, or about 25s per year. Taking an average number of over 200 lamps per day during a period of 18 months, it was found that each lamp used 6 inside glasses per annum, and that an outside glass lasts 18 months, a gauze about 2 years, and a perforated cap, 3 years—first cost, 8s 3d to 9s 6d.

LIGHTING POWER,

Tested by a Photometer at Hamilton Gas Works.

	Number of lamps to equal 1 candle.	Candles.	Burning
Dr. Heinzerling's Lamp, ...		1·30	Paraffin Oil.
Debrulle Mueseler, ...	2·49 =	1·00	Sweet (Colza) Oil.
Dr. Irving's (Singing Lamp),	2·33 =	1·00	Naphtha Spirit.
Naked Lamp (Young's pattern),		1·24	Paraffin Wax.
Do.,		1·40	Sweet or Colza Oil.
Scotch Gauze (small), ...	2·35 =	1·00	Do.
Do., (large), ...	1·64 =	1·00	Paraffin Wax.
Davy Lamp, ...	6·17 =	1·00	Sweet Oil.
Mueseler (Belgian pattern), ...	2·51 =	1·00	Do.
Protector Mueseler, ...	2·02 =	1·00	Naphtha Spirit.
Williamson's Lamp, ...	1·54 =	1·00	Sweet Oil.

EXPERIMENTS AS TO LIGHTING POWER OF SAFETY LAMPS,

Tested at Earnock Colliery.

The quality of the light was tested in a working place by placing the superior lamp say about 164 feet from the observer, and then shifting the inferior light nearer the observer till the lights were apparently of the same value.

Swan's Incandescent Electric Light,	1 = 2·39	Dr. Heinzerling's.
Dr. Heinzerling's Lamp, ...	1 = 1·29	Crossley's.
Do., ...	1 = 3·55	Mueseler Protector.
Do., ...	1 = 2·92	Williamson's Lamp.
Williamson's Lamp, ...	1 = 3·17	Austine Davy.
Do., ...	1 = 4·10	Jack Protector.
Do., ...	1 = 3·81	Davy.
Do., ...	1 = 4·42	Stephenson.
Do., ...	1 = 1·27	Mueseler Protector.

Deduced from above experiments—

Takes 6·97 Williamson's Lamp = 1 Electric Light.

Takes 8·48 Mueseler Protector = 1 Do.

Kind of Lamp.	Where Used.	Size of Gauze.		Size of Glass.		Weight when Full.	Cost of Lamp.	Oil, Cost per Day.	Repairs per year.	Lighting power of Candles.	Total cost of 100 lamps per annum (300 days).
		Ht.	Dia.	Ht.	Dia.						
		Ins.	*Ins.*	*Ins.*	*Ins.*	*Lbs.*	*s. d.*	*d.*	*s. d.*		
Davy (Colza oil)	Blantyre	6	1½	...	...	2⅛	4 0	·375	1 0	0·16	£61 17 6
Mueseler Belgian (Colza oil)	...	4	1¾	2⅜	1¾	...	5 9	...	...	0·40	...
Mueseler Protector (Naphtha)	Backmuir	4⅛	2¼	2⅜	2⅜	3⅛	12 6	0·295	0 7¼	0·49	40 5 5
Naked light (oil)	...	...	...	...	...	¼	0 2	1.25	...	1·40	156 5 0
,, Paraffin wax		...	...	...	...	¼	0 2	1	...	1·24	125 0 0
Scotch gauze (Colza oil)	Allanshaw	10	3½	...	...	1¾	3 9	1	6 6½	0·42	157 14 2
,, Paraffin wax	,,	,,	,,	...	...	...	...	·90	...	0·61	145 4 2
,, Colza oil	Bent	11	3¼	...	...	...		0·99	6 9	...	157 10 0
,, Colza oil	,,	9	3								
Williamson (Colza),	Cadzow	3½	2⅛	2⅜	2½	3 1/16	8 3 9 6	0·88	2 11	0·65	125 0 0
				Inside. 4¾	1¾						

the subtle nature of the "electric fluid;" and that, whereas ordinary workmen can repair the ordinary hammer and wire form of signalling apparatus, skilled workmen must be employed to find out and repair any fault in the electric system; in short, that the whole thing is too refined and complicated for the ordinary rough work about pits. These difficulties are not unsurmountable, and if fairly dealt with will disappear. The express purpose of this paper is to convey such directions for keeping electric bell signals in working order as may prove useful to those who have experienced trouble and annoyance with bells ceasing to work, apparently without cause. A cause, however, does exist, and can easily be found; and if these remarks convey instruction the end will be attained which led to the writing of this paper.

The following notes are the result of an investigation into the whole subject; and after our experience we can see no difficulty in keeping the simple apparatus required about a colliery in good and efficient working order, and that by any man of ordinary ability.

In every system of electric signalling the first important part to be considered is the battery. If it be allowed to get out of order, there can be no hope of success. Of batteries there are numerous forms, but it will be unnecessary to mention any other than the Leclanche, which is a good serviceable battery, low in first cost, easily put together, and maintained at a small cost. It has also one very decided advantage over most of the other forms, viz., when it is not in use there is no waste of material. It is not, however, suited for heavy continuous work (as on a very busy telegraph circuit) as it becomes "polarised," *i.e.*, the hydrogen is generated too rapidly, and, adhering to the carbon element, prevents the free access of the fluid. When this occurs the battery ought to be left at rest for a short time, when it will be restored to its primary strength. Before proceeding further, it may be as well to explain in detail the construction of, and the action which takes place in this battery. A cell or jar of biscuit porcelain (which is very porous), has fitted into it a plate of carbon having on its top a lead cap which carries a brass binding screw; around this plate, and to completely fill the porous jar, is tightly

packed a mixture of needle (binoxide) manganese and carbon in the form of a rough powder, the top of the jar and lead cap being covered over with marine glue to keep the contents secure and also to prevent the lead being acted upon by the liberated ammonia. The porous centre is placed in a glass jar (or one of earthenware) along with a rod of zinc, properly amalgamated with mercury, having a copper wire cast into the upper end, the exposed portion of which ought to be covered with tarred tape to prevent corrosion. In the newer forms of this battery, the porous jar is dispensed with, the binoxide of manganese and carbon powders being pressed into solid blocks. Two of these blocks with the carbon plate between them are held together by means of strong indiarubber bands, having pierced projections on one side through which the zinc rod is passed. It is thus always kept in one position, and prevented from coming into contact with the carbon element. The carbon and binoxide of manganese act in this battery in a similar manner to the copperplate in many others, and the current generated from this pole is generally called the "copper current," and is so to be understood.

The medium which is used for exciting this battery is a solution of chloride of ammonium ($N.H._4 Cl.$) or sal-ammoniac as it is commonly called. A strong aqueous solution of this salt is made, and, for reasons which will be mentioned further on, the stronger this solution is the better. A supply of this solution ought always to be kept in readiness, contained in a glass or earthenware jar. In the action which takes place, chloride of zinc is formed, ammonia is set free at the zinc electrode, whilst the hydrogen in a nascent form reduces the binoxide of manganese to the state of sesquioxide. $Zn + 2(NH_4 Cl) + 2\ Mn\ O_2 + C = Zn\ Cl_2 + 2\ NH_3\ H_2\ O + Mn_2O_3 + C.$

"So long as chlorine only is set free at the positive plate and ammonium liberated at the negative, so long is galvanic polarization averted; but as soon as oxygen arises at the zinc and hydrogen unconsumed accumulates on the carbon, which actually does occur after continued working for a few minutes, that moment polarization ensues, a counter current is generated and the resultant strength of current obtained from the battery is

impaired. This galvanic polarization, along with every trace of secondary action, speedily disappears if the battery be left to itself; *it is not observable at all if the battery is called into play only at intervals.*"—PREECE.

In setting up a battery on the Leclanche system the following precautions must be observed :—

a—To see that every terminal and connection is clean and bright, the nuts being firmly screwed down on the wires to insure close and perfect metallic contact.

b—To instantly remove any white incrustation (oxychloride of lead) which may form on the cap on the top of the carbon pole, and any green crust (verdigris) on the brass terminal or copper connecting wires.

c—To keep the height of the solution uniform in every cell, each being not more than two-thirds full, and to be attentive that there are no empty cells in the series, as the existence of one empty cell will destroy the circuit.

d—To have all the cells forming the battery of one uniform size, and not to have large and small cells in the series.

e—To keep the connecting wires perfectly insulated (otherwise they will soon be eaten away by the liberated ammonia) and clear from all parts of the battery except their own connections as, if an uninsulated wire should come in contact with another carbon other than its own, short circuiting will ensue, and the power of the battery will be reduced.

f—After the lapse of a few weeks or months, according to the amount of work the battery is called upon to perform, the liquid in the cells will become milky; this is owing to the removal of nearly all the chloride of ammonium from the solution, which, becoming weak, is unable to dissolve the double salts of oxychlorides of zinc and zinc ammoniac chlorides, which are formed when the battery is in action. These salts are, however, freely soluble in a concentrated solution of ammonium chloride. The exhausted solution is to be withdrawn and the cells refilled with a fresh quantity of the solution, and the more concentrated it is the better.

g—When working about the battery and connections, great care must be taken to have the hands clean and perfectly free

from oil or grease, as these substances act as insulators, and their presence will destroy the continuity of the circuit.

When properly set up and a moderate amount of attention given to it, this battery will last for a long time and give very little trouble. It ought to be kept in a dry and moderately warm place where it is perfectly secure from frost, as cold will stop the action. It must also be well insulated, or a part of the current will escape to the earth. As the action of the battery is to eat away (*i.e.* to dissolve) the zinc rods, they must be renewed from time to time. It is not absolutely necessary to amalgamate them, but it is much more satisfactory to do so, as the zinc employed is never pure, and on that account secondary action is very apt to set in, which causes unnecessary waste. The contents of the porous centres also become reduced from the state of binoxide to that of the sesquioxide, and when this occurs the battery will cease its action. Such of these centres, therefore, as may become exhausted must be removed and replaced by fresh ones. These exhausted centres are to be well soaked in water for a few days (the water being frequently changed) and afterwards freely exposed to the air in a clean place free from dust. The sesquioxide will gradually absorb oxygen aud become converted into the state of binoxide—$Mn_2\ O_3 + O = 2Mn\ O_2$—and the oxidised cells may be again used. This operation can only be once performed however. If the current suddenly ceases, or becomes very feeble and gradually ceases, the stoppage is due to one or other of the above mentioned defects, which must be looked for and made good.

In setting up a battery, the copper wire from the zinc is connected with the carbon on the next cell, and so on in like manner for every cell, so that by commencing with the first zinc put to earth the last cell of the series will have its carbon pole left free and unconnected; this is called coupling up a series for intensity current, *i.e.*, each cell adds to the potential of the current. Thus, if we have four cells, each having an electromotive force of 10, the four cells thus coupled up will have the electromotive force (EM.F) raised to 40, though there is no greater quantity of electricity produced from the four cells than would be produced from one, but if all the zincs be connected together, and the four

carbons also connected with each other, the quantity of electricity produced will be four times that which would be produced from one cell, but the EM.F will only be 10, or the same as for one cell. In signalling we, however, require an intensity current, therefore the cells must be connected in the manner first mentioned—*i.e.*, zinc to carbon throughout the series.

To determine whether the battery is in action or not we use an instrument called the galvanometer. The wires leading from the zinc and carbon elements are to be joined in circuit through the galvanometer (see Fig. 1). If the battery is at fault the needle will not be deflected, but if the battery is in working order the needle will be deflected by the passage of the current. Supposing that no deflection of the needle results from the completion of the circuit, recharge the cells with fresh chloride of ammonium. If no deflection of the needle results, one or more of the porous centres must be exhausted, and every cell must now be tested separately by means of the galvanometer, in the method already described, and the faulty cells giving no deflection of the needle must be removed and new ones inserted.

When the battery consists of a large number of cells, the process of testing each one separately occupies a considerable amount of time, and as any fault showing itself in an electric system of signalling may be first assigned to the battery, it is advisable to have one or two resistance coils in connection with the galvanometer, which can be cut out, or put into the circuit, at pleasure. Resistance coils are simply bobbins, wound with a varying length of fine copper or German-silver wire, covered with silk, and thoroughly insulated with paraffin, and form what is called an "artificial line." The length of wire in these coils will of course depend upon the circumstances under which they are to be used, but in all cases the resistance introduced ought to exceed the total resistance of the line wires, keys, bells, and connections. If, then, in first testing the battery, this resistance is introduced into the circuit and the needle is strongly deflected, we may safely assume that the fault does not exist in the battery, but if no deflection occurs, then, each cell may be separately tested, if recharging with fresh solution and cleaning the connections have not the desired effect. A fault may occur

in the wires, bells, or keys, and we, assuming it to be in the battery, waste perhaps an hour in testing each cell separately, and after all find that the fault exists elsewhere; whereas by having at command an artificial line, the power of the battery can be determined in one or two minutes.

The simplest form of galvanometer (and the only one necessary for colliery work) consists of a magnetic needle surrounded by a coil of perfectly insulated wire, the thinness of the wire and the number of convolutions which it makes determining the resistance and the sensitiveness of the instrument. The needle generally passes over a graduated scale of degrees, the scale being divided from 0 to 90 to the right and left, as in a compass, having each quadrant divided.

For colliery work, a galvanometer or detector, having a resistance of 60 ohms will suffice, and when supplemented with the resistance coils previously mentioned all necessary testing can be easily performed. When resistance coils are attached to a galvanometer, the wire must not be wound on the bobbins in one continuous length, but half the length must be wound to the right, the other half being wound to the left, so that the course of the current may be reversed, which will prevent self-induction.

CONDUCTING WIRES.

The wires which are used in conducting a current of electricity from one point to another are either copper or iron, and they are either covered with some insulating material or are left bare, the insulation being obtained by other means. The class of work and the position in which the wires are to be placed will determine the kind of wire to be used. Copper wires are insulated with cotton, silk, india-rubber, or gutta-percha, the last mentioned being the material most generally employed. Iron wires are, as a rule, left bare, being supported on insulating cups of glazed earthenware, glass, porcelain, or ebonite. A sufficiently large wire ought to be employed to reduce the line resistance as much as possible, and this resistance lessens as the size of the wire increases, the ratio being as the square of the diameter. The metal of which the wire is made has also a great effect upon the resistance;

and if wires of silver, copper, iron, and lead were tested, it would be found that silver offers the least and lead the highest amount of resistance.

For shaft work, copper wire is the most suitable, and it may be insulated with india-rubber or gutta-percha. The latter material should not, however, be used alone: for, although having a very high insulating power, exposure to air and moisture renders it hard and brittle, and in this state is very apt to crack, causing leakage, which, if the shaft is a wet one, will be sufficient to make total earth, *i.e.*, the current will find its way to the earth and will cease to actuate the hammers of the bells. In all cases therefore, the gutta-percha covering ought to be served over with tape saturated with Stockholm tar, which has the effect of keeping the percha soft and pliable; and wires thus treated, though a little more expensive in first cost, are in the long run very much cheaper. Shaft wires ought also in all cases to be embedded in strips of wood suitably grooved to receive them, and covered over with a thin strip tacked on to the lower piece, which will keep them free from atmospheric action. This sort of wire ought in all cases to be employed in making connections with batteries, keys, or bells, and when No. 16 or 18 B.W.G. is used, this size of wire will be found amply sufficient for any signalling which may be required about a colliery.

For underground work, however—as carrying lines of wires along the levels, or to the rise or dip workings—the circumstances of the mine and the desired mode of signalling will determine the class of wire to be employed. Thus, if it is required to transmit signals from given stations only, some form of insulated copper wire might be employed contained in grooved strips of wood placed along one side of the roadway beneath the ballasting. This system has the advantage that, in the event of falls of roof or sides occurring, the wires are little liable to be damaged. But if it is desired to transmit signals from all and every point of the roadway, the wires must then be carried along the side of the road, and at a sufficient height to be free from all chances of being caught and broken by passing hutches or other causes, except falls of roof or sides. In this case, the wire employed should be made of best charcoal iron, galvanised, and weighing

about 211 lbs. per mile, as an iron wire is very much stronger than a copper one, and, although iron is inferior to copper in conducting power, yet the increased section of the iron wire will neutralise its lesser conductivity. As there is no insulating material covering these wires, they must necessarily be carried on some insulating material at the points of support. Such insulators are most commonly made of porcelain, which serves the purpose very well; but there is always more or less leakage in an overhead line of uninsulated wire, as these insulators become dirty from accumulation of dust or the condensation of moisture upon them. A path is formed by which more or less of the current finds its way to the earth, and, although the leakage at each point is generally very small in quantity, yet, owing to the oft-recurring points of contact made by the wire, the sum of all such small leakages may amount to a very considerable quantity in a long length. There has very lately been introduced by Messrs Berthould & Borel, of Paris, a class of insulated wire, which from the description given appears to be the best suited for shaft and underground work generally, where an insulated wire is required. The wire is first insulated with several thicknesses of cotton, wound in opposite directions. The wire thus covered is then plunged into a bath, composed of paraffin and colophane, which is kept at a temperature of 392°. Any moisture which may exist in the cotton is expelled at this temperature, and the mixture penetrates the covering and insulates the wires which are then covered over with a lead sheeting. From experimental trials which have been made, this insulating material is superior to either india-rubber or gutta-percha. At present there are seventeen different varieties of this covered wire made, which contain from one wire No. 6 to seven cables of 7 wires each of No. 25 for telegraphic and bell work, to fourteen lines of 3 wires of No. 25 for telephones. The price ranges from £10 to £170 per mile, while for a single wire of No. 16 wire covered with gutta percha to No. 6 is £41, and for No. 18 wire covered to No. 12 is £15 per mile, whilst for taped and barred gutta-percha wire No. 18 covered to No. 11 the price is £22 10s per mile. The new form of wire, therefore, compares favourably, so far as first cost is concerned. The table given beneath shews

approximately the length in yards of, and the resistance offered by, one pound of copper wire of different sizes, as given by Culley :—

Birmingham Wire Gauge, No., ...	12	14	16	18	20	22	24	26	28	30	32	34	35	36	38	40
Dia. of wire in decimal parts of an inch,	·109	·083	·065	·049	·035	·028	·022	·018	·014	·012	·009	·007	·005	·004		
Approximate No. of yards in 1 lb., ...	9·7	16	26	44	69	123	178	278	434	569	1111	1231	1538	1736	3086	6944
Resistance in ohms of 1 mile, at 32°, ...	4·6	7·5	12	21	33	60	85	133	207	270	530	588	734	829	1473	3315

JOINTING OF WIRES.

The operation of joining two lengths of wire together is one which is of first importance, and cannot be performed too carefully, as, if the joinings in a long length of wire are imperfectly made or are dirty when made, a great amount of additional resistance will be introduced into the line, which may be sufficient to entirely stop the current from flowing unless increased battery power is applied. In jointing a copper wire insulated with gutta-percha, it is necessary in the first place to strip off about two inches of the covering from the end of each wire; the ends are to be thoroughly scoured with emery cloth until perfectly clean and bright. These ends have now to be twisted together in the manner following :—Cross the wires as in the letter X; there are thus four parts—the two main wires and the two loose ends; hold three of those parts firmly, and twist one of the loose ends on the bared portion of the wire next to it. When the twisting is completed, repeat the same operation with the other loose end; the two wires are now thoroughly jointed to each other and cannot be drawn apart, unless pulled very strongly. The coils of the twists must be close to each other and must be drawn very tight on the wire to insure close metallic contact. Now have ready some strips of gutta-percha about one inch broad by $\frac{1}{16}$ or $\frac{1}{32}$ of an inch in thickness. Heat a portion of this strip, and also heat the percha covering of the two wires, so that it may be perfectly soft (but not burnt—in heating the percha it ought neither to drop nor to flame). Apply now the hot strip on the uncovered

portion of the joint, pressing it well together with the fingers, and joining the new percha with the original covering of the wires so as to make all a solid mass. When the percha is very soft it is apt to stick to the fingers, but this can be prevented by moistening them with a little water. The joint must be frequently heated and thoroughly kneaded together to insure homogeneity of the whole part operated upon. Berthould & Borel's wires may be jointed in like manner, covering the joined portion with cotton thread, brushing on the insulating material (paraffin and colaphane kept at the melting point) to thoroughly saturate the cotton, and finishing off the joint with a thin piece of lead wrapped round it and soldered along its edge and at the ends of the enclosing tubes.

When iron wires are used, a different sort of joint must be employed, as these wires are too stiff to be twisted together. There are several methods of jointing iron wires together, but it will be unnecessary to consider any other except the "Britannia joint," introduced by Mr Edwin Clark, as this is the most perfect form of jointing such wires together, and the one which is now universally adopted in telegraphic work. The ends of the two wires which are to be joined are perfectly cleaned and made bright by scouring or scraping for a distance of two inches, the wires are then laid side by side and firmly bound together with No. 16 binding wire. The ends of the two wires are slightly turned up, and the binding wire is first very tightly rolled five or six times round the single wire to the left hand of the joint, the winding is then continued along the whole length of it and is finished off with five or six turns on the single wire at the right hand side. The coils of binding wire must be close together and the joint soldered; no electrical joint can be considered perfect without soldering. Any long ends must be cut off as short as possible, and the nearer a joint is made to a point of support the better. In soldering copper wires together, rosin must always be used as the flux, but, with iron wire, "Spirit of Salt" may be used, but never with copper.

In terminating, the wire is simply turned round the porcelain insulator, the loose end laid along the main wire, and the two are firmly bound together. Of course, the wire must terminate at each end of the line. Now, suppose the roadway has been

driven on a further distance, requiring an extension of the line, put up another insulator near to the last (of the original line), terminate the new wire thereon, and join the new and old lines together with a short piece of insulated copper wire.

RANGING LINES OF WIRE.

Ranging a line of insulated copper wire is not at all difficult: the pieces of grooved wood already mentioned are first placed in the desired positions, the wire is placed in the grooves, and the covers fastened on. There may be places where the wire does not require to be thus protected, as in roofed pithead-houses and other buildings, where the wires may be carried along wooden beams used in the construction; in such cases *metal staples* should never be used, as in our experience the percha covering is soon destroyed at the points of contact and leaks occur, which have frequently the effect of making the signals very irregular. The best materials for securing the wires in such positions are strong linen tape, good canvas, or a thin cloth made with layers of canvas and India-rubber. Any of these materials will suit, but we give preference to the last. A narrow stripe is passed over the wires and tacked to the beam at the top and bottom and between each wire. By this all the wires are kept separate and distinct, and each wire can be very easily traced when desired. It is a very great convenience when carrying a line of wires through any building to have them above the floor; they are thus readily seen and repairs are more easily made.

Uninsulated iron wire must, however, be treated differently, and as the natural tendency is to pass the current to the earth, it must be supported on some material which possesses insulating properties at every point at which the wire is supported. Insulators for this purpose vary in form and material, but we will only consider those made of porcelain. The simplest form is a cup with an iron bolt cemented inside, having a groove formed round the exterior near to the top (See Fig. 2). Another form is to have two cups, the one cemented inside the other. To the inner one the iron bolt is secured—the cement which is used being generally Plaster of Paris. The double cup may be said to give double security against leakage; but in short lines such as exist in

collieries, the single insulator will be found sufficient. We will suppose that it is desired to signal from every point in the length of the road, along which the hutches have to pass. Two wires must, in this case, be ranged along the whole length of the roadway: the one leading from the carbon element of the battery (the zinc being put to earth) and the other connected with the bell or bells. These wires are to be supported on insulators placed at regular distances of fifty or sixty yards apart on the straight portions of the road, but in passing round bends or curves they must be placed much closer together so as to prevent the wires coming into contact with the sides of the road. Only the best wire ought to be used, and got in as long lengths as possible to avoid the recurrence of frequent joints. Where the roadways are bricked, the brackets carrying the insulators can be driven into the joints, but where timbering is adopted, strong trees must be put up at the proper distances, a hole being bored through each for receiving the insulator bracket which is secured by means of a nut at the back. These trees or posts must be entirely independent from the usual timbering put up to secure the roof or sides. After the insulators have all been put up, the wire is secured to the first terminating insulator and stretched along the roadway. The loose end is then attached to a set of light blocks and tackle and tightened up, not too tightly, however, or it will be broken. (The maximum tension put upon any wire is not to exceed one-third of the breaking strain—a No. 8 wire not being strained to more than 400 lbs., and a No. 11 wire to more than 200 lbs.) Wires can never be drawn perfectly straight, there being always a "sag" or dip between the points of support, which varies with the temperature. At 60° Fah. the accepted dip is 24 inches in a span of 100 yards. It varies also directly as the square of the distance, or expressed as a formula: Let $d =$, the dip in 100 yards, D = 100 yards, e = the given span, and x = the required dip for the given span, then $D^2 : e^2 :: d : x$, and taking the span previously given as suitable for underground roads, viz., 60 yards, we find that the dip is 8·64 inches. The wire is now placed in the grooves of the insulators and firmly secured thereto. This may be done by binding as follows:—A length of about three feet of binding wire is cut off and eight or nine turns are firmly

rolled round the main wire (commencing, say at the left hand), the loose end is passed round the groove (at the back) of the insulator and wound eight or nine times round the line wire at the right hand and returned round the insulator back to the left hand, where the remainder of the binding wire is again rolled round the line. The whole joint is then securely soldered. Another method* of securing wires to insulators is to have a bow made of $\frac{1}{2}'' \times \frac{1}{4}''$ iron, the two ends being turned up about 1" or $1\frac{1}{2}''$ into the form of hooks which engage the line wire. The bow is slipped over the back of the insulator, and the connection is made. Fig. 2 shows the arrangement. Another method† is by a new form of insulator which is made in two parts, attached by means of a screw-thread. The body of the insulator has formed on its top a screw, and it is also slotted. The wire is placed in this slot, and a cap, also screwed, operating upon a serrated grip of steel, is screwed on to the top. The steel grip is thus firmly pressed down upon the wire which is held very securely in its place. A sketch of this insulator is given (Fig. 3) which clearly shews its construction. This is considered decidedly the most suitable form for colliery work.

As in this system of signalling two wires are required, we would advise that the erection of one wire is completed before commencing with the other, so as to avoid mistakes in position.

The wires are now supposed to be erected, joints perfectly made, and all the connections with bell and battery complete. The wire from the battery may be said to be always fully charged with electricity, seeking its way to the earth or back to the battery through the negative element (the zinc). So long as the wires are separate and thoroughly insulated the circuit cannot be completed; but if the wires are brought together so as to make contact, or if there is very defective insulation, then the circuit will be completed, and a current will flow through the line and bell either to the earth or to the zinc element of the battery. An illustration of this system is given in Fig. 4.

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* Designed by Mr E. Gilbert, of the Dundee and Arbroath Joint Railway.

† Invented by Mr Charles E. Crighton, of Newcastle-on-Tyne.

We believe that both of these methods for securing wires to insulators are protected by patent.

THE EARTH AS PART OF THE CIRCUIT.

The resistance offered by the various rocks composing the earth's crust to the free flow of electricity through them varies to some extent; and all of them are greatly inferior in conductibility to a metallic body having the same area of cross section. When, however, it is considered that the earth is infinite in size in comparison with any conducting wire employed in telegraphy, the high resistance shewn by small sections of the rocks entirely disappears, and it may be considered as being a perfect conductor. When a current of electricity is generated in one part, and transmitted by means of a conductor to another part, the current so transmitted must return to the place whence it originated, (*e.g.*), suppose we transmit a current from the carbon pole of the battery to a distant point, there must in like manner be a conductor from that point to the zinc pole of the transmitting battery to complete the circuit. For this purpose a second or return wire might be introduced, which, however, would add to the first cost, and is quite unnecessary, for, owing to the perfect conductibility of the earth, it may be made to serve the purpose of a return wire. At each end of the line, and at every bell or signalling apparatus on that line, a large metal plate is buried in the earth, each plate having a wire firmly attached, which is connected to one terminal of the batteries, bells, or other instruments. Earth plates ought to be at least two feet square, and buried deeply in moist earth or clay, or placed in a pond, sump, or stream, so that they are in a position which is constantly damp. Although any metal will suit for earth plates, care must be taken that all such plates in one circuit are of the same metal. If we decide upon copper, iron, or zinc, every earth-plate must be either of copper, iron, or zinc. It will not do to have one plate of copper, another of zinc, and another of iron, because opposed plates of different metals constitute a battery, and a current would constantly flow from the one to the other, and electrical action would be developed in the battery which would cause great waste of material and polarization. They may be of galvanised iron having a stout galvanised iron wire, No. 11 or 12, securely soldered to each. The best plates are, however, made of copper,

with copper wires attached, as copper is a much better conductor. It is also necessary when putting two batteries to earth, that like poles are opposed, the usual practice being to put zinc to earth, and carbon to line. If the zinc of one battery and the carbon of another, both working on one circuit, are respectively put to earth, the circuit will be completed, and the battery will be kept in a constant state of action until polarized.

The following experiment was made to show the result which would follow by connecting opposite poles of the battery with the earth, and also the result of forming the earth plates of different metals. The zinc and carbon poles were put to earth through plates of zinc (Zn), copper (Cu), malleable iron (MI), lead (Pb), and cast-iron (CI).

Earthplate of	Zn	from Zinc pole,	and Zn	from Carbon pole,	Galvanometer deflected, 35°
,,	Cu	,,	,,	,,	55°
,,	MI	,,	,,	,,	55°
,,	Pb	,,	,,	,,	60°
,,	CI	,,	,,	,,	60°

When the zinc poles of both batteries were put to earth through different metals the results were :—

One Earth Plate	Zn,	the other	Cu,	Galvanometer deflected,	15°
,,	Zn,	,,	MI,	,,	32°
,,	Cu,	,,	MI,	,,	20°

The arrangement of the batteries, etc., employed in the foregoing experiment is represented in sketch V., where E.E. represent the earth plates, Z.Z′ the zinc poles of the two batteries, C.C′ the carbon poles, G the galvanometer. Although in the experiment just mentioned batteries were employed, they are not necessary for showing the existence of electrical action, for if a plate of zinc and another of copper are placed in a mixture of clay and ashes moistened with water, the circuit being completed through the galvanometer, the needle will be deflected, proving the existence of a current flowing from the one plate to the other; and plates of various other metals when thus opposed to each other will generate electrical action.

Where there are gas or water pipes convenient, these may be used for making an earth connection by attaching the earth wires thereto. The portion of the pipe to which the wire is to be con-

nected must be thoroughly cleaned by scraping, to have a clear metallic surface, and the wire twisted round it five or six times (very tightly) and the joint perfectly soldered. When the pipes are made of iron they must first be tinned before soldering. Pipes which are warm, such as steam or feed pipes, should never be employed for this purpose, because the resistance increases with the temperature. At the bottom of the pit, the earth wire may be attached to the plates or rails, but it is much better to place a plate in the sump and connect all the return or earth wires at that point thereto. Pit rails are rarely fish-plated, so that every joint makes a break in the return line, unless the ballasting of the roadway is damp. In a very dry pit it would be advisable to put in a return wire, which need not be insulated in any way; it may either be laid along the floor or stapled to the timbers in the roadway. When it is desired to transmit a signal from any point in the roadway along which the wires are carried, it is only necessary to press the two wires together, when the circuit will be completed through that point of contact. But when wires are employed which are entirely insulated a signalling key has to be inserted in the line at every point from which it is desired to transmit signals. The key (Fig. 6) consists of a wooden, ebonite, or porcelain board, carrying a brass lever supported at the centre and having a contact piece at each end, the actual points of contact being formed of platinum. Attached to the back end of the lever is a spiral spring, which keeps the lever down upon the back contact piece. At one end of the board (or in any desired position thereon) are placed two or three brass terminals or binding screws, which may be numbered from the right hand 1, 2, and 3. These terminals are connected with wires to the contact pieces in the manner following:—No. 1 to front contact, No. 2 to central support of lever, and No. 3 to back contact and spiral spring. To No. 1 is connected the wire leading from the carbon pole of the battery. It will be seen that the front contact piece is in direct connection with the battery, but the lever is prevented from touching it by the action of the spiral spring at the back. No. 2 may be connected directly with the local bell, and No. 3 is attached to the line wire. It is advisable to have the same arrangement on every key, and to remember what

wires are connected with the different terminals. Dr. Siemens, of London, has introduced a key carried on an ebonite board upon which all the internal connections are very clearly shown in white lines. To transmit a signal, the lever is depressed, the connection with the back contact is broken, and the circuit is completed by pressing the lever down upon the front contact, which, being in direct connection with the battery, causes a current to flow through it, the central support, lever and spiral spring, and by the internal connections the current is divided, passing through the terminals Nos. 2 and 3, one portion passing through the coils of the local bell, and the other portion passing to the line wire. At No. 2 bell and key the current is again divided as before. All the bells therefore are in direct connection with each other by means of the keys, the levers of which are kept down upon the back contacts. Any number of bells may thus be joined up in one circuit, but every extra bell demands an increase of battery power, as a current of electricity when divided loses strength. Two bells will require a current the potential of which is more than twice as great as would suffice for one bell. The greater the number of bells inserted in one circuit the greater must be the resistance inserted in each coil either by employing a longer length of wire, or a finer one, as electricity will take the easiest path to the earth, unless restrained by a higher power of resistance in the instruments.

A.—In the case of a shaft fitted with electric signals, on the system of which a sketch is given, whereby any signal transmitted by the bottomer is received by the pitheadman and engineman or *vice versa*, three bells being employed, and where the total resistance of the bells, keys, line wire, and connections amounts to 200 ohms. If at any time the signals cease, or are transmitted irregularly, the faults which may be suspected are :—

a.—Empty or exhausted cells, short circuiting in the battery, or disconnection.

b.—Leading wire from battery to key, from key to line, or from key to bell disconnected, broken, or corroded.

The battery is now to be tested by means of a galvanometer and resistance coils. If on completing the circuit the needle is

strongly deflected the fault does not exist here, but must be searched for amongst the wires and connections. If no deflection of the needle results, the battery must then be tested cell by cell, or re-charged with solution of chloride of ammonium and again tested as described before.

B.—A feeble current passes which may or may not ring one or two bells. The faults in this case are:—

a.—If the line wires and connections are all in good order—partial exhaustion of the battery.

b.—Corrosion of the wires, thus reducing their area and increasing their resistance.

c.—A combination of both these causes.

C.—The current entirely ceases:—

a.—One or more of the battery cells empty.

b.—Exhaustion of the exciting solution.

c.—Reduction of the peroxide of manganese to the state of binoxide in one or more of the porous centres.

d.—Total disconnection or breakage of some of the wires.

D.—Searching for and localising faults:—

a.—A careful and searching examination of the battery and connections to see that they are all clean; that none of the cells are empty, and that the nuts are firmly screwed down upon the connecting wires.

b.—Examination of the keys and connections to see that they are all clean and bright. In cleaning the key from any dust or dirt which may collect upon it, cotton waste ought not to be used, as threads are very apt to adhere to it, and if one of such threads should be across the front contact, this is sufficient to prevent the current from flowing, as cotton is a non-conductor.

c.—Examination of the line and other wires for continuity and firm connection with their respective terminals or binding screws.

E.—If the battery is in perfect working order, the connections clean and in firm metallic contact, but signals cannot be transmitted, the fault must be searched for amongst the wires, keys, or bells by means of the galvanometer.

a.—First test the keys for continuity of the internal connections; connect the battery wire with terminal No. 1 and No. 2 with the galvanometer, which is also put to earth through its other terminal. Now depress the key so as to complete the circuit through the front contact; if the connections are perfect a current will flow through that terminal, galvanometer, and to earth, deflecting the needle. Remove the connection of the galvanometer from No. 2 and connect with No. 3 of the key and test this in the same manner. If, however, any of the connecting wires in the key are broken, the needle will not be deflected, and a fault exists in the key.

b.—To test the continuity of the line or any connecting wire—Connect one end of the wire with the battery, and the other end with the galvanometer, which is put to earth through one of its terminals. If the wire is continuous the needle will be strongly deflected, but if broken there will be no deflection.

c.—If the wire is broken the position of the break must be searched for in the following manner:—connect one end of the wire to be tested with the battery, the other end being put to earth. Provide two sharp steel probes or needles, each having an insulated copper wire firmly soldered to the top or blunt end. A still better method is to have two brass holders for containing the needles having a terminal at the upper end by which the testing wires can be easily attached, the portion which is held in the hand being insulated with gutta-percha or other material. The free ends of the testing wires are then joined through a galvanometer, and one of the probes inserted through the insulating material on the line wire until it is in free metallic contact therewith. If the testing is commenced at the bottom of the shaft, this probe is to be inserted at a point as low down as possible in a portion of the wire which is known to be perfect. The other probe is now inserted at a point higher up the shaft. If the break exists at a point between these two probes the current will have a free course from the battery to the earth, through the probes, testing wires, galvanometer, and the unbroken portion of the line wire, and the needle will be deflected, but if the break exists at some point beyond the upper probe the needle will not be deflected. The second probe is now to be

moved a stage higher up, and contact again made with the line wire, and this operation repeated as often as may be necessary until the position of the break is roughly ascertained. To retain the one probe always in its first position, *i.e.* at the bottom of the shaft, might necessitate a length of testing wire equal to the whole depth of the shaft, which is not advisable, and to avoid this the two probes may be moved up together. It is, however, always necessary to ascertain that the lower probe is in connection with the battery, and this can be very simply tested. Suppose the lower probe has been moved up a distance of 40 feet, the upper one being 12 feet above it, when the lower probe is brought in contact with the line wire, the upper one is made to touch the earth (*i.e.* the side of the shaft). If the line wire is perfect below the lower probe the current will flow and deflect the needle, and a further length of line wire can then be tested. A rather long length of testing wire is, however, in the first case advisable, as it enables a greater length of line wire to be tested at once, and when the fault is located between two fixed points, the line between those points may be tested in lengths of one or two yards. The testing may from the first be carried out in short lengths, and the extra trouble may more than counterbalance the inconvenience of having to contend with long lengths of loose wire hanging in the shaft. Another method is to carry on the cage a small testing battery of three or four cells, to which the testing wires are connected. Both ends of the line wire are to be disconnected from the earth, and progressively tested by means of the probes; so long as the wire is entire between the two probes, the needle will be deflected, but when the break exists between them it will not be deflected. At least two men are required for this operation of testing, each of them operating one probe, and when the cages have two or more decks, one man may be stationed on the lower deck and the other on the cover of the cage. When a defective portion of the wire has been cut out and replaced with a new piece, the joints should be thoroughly cleaned with emery cloth, firmly twisted together, soldered, and perfectly insulated with thin strips of gutta-percha, put on hot and thoroughly kneaded with the fingers. As the gutta-percha cools it must be re-heated, as also the covering of the

original wire, so that the new gutta-percha may be thoroughly and perfectly jointed with the old. A spirit lamp is the best medium for heating the gutta-percha, as the flame from methylated spirit is clean, and there is no chance of oil or tallow coming into contact with the gutta-percha, the presence of which would prevent a perfect junction. When jointing, the fingers must be kept damp ; water suffices if the joint is frequently heated, but naphtha is the superior fluid. The holes made by the probes are very small and are easily closed by slightly heating the percha and pressing it together with the fingers, which should be done at once. This method of testing by means of probes is superior to cutting out portions of the insulating material, as is sometimes done. The operation of testing a line wire for breakage is very troublesome, but, fortunately, is one which is very seldom if ever required if the wires be put in properly at first.

d.—If, after testing the battery keys, connecting and line wires are found intact and free from faults, yet signals cannot be passed, the fault must be looked for in the coils of the bell magnets, their connections, or the earth wire. The continuity of the wire in the coils and connections can be very simply tested by connecting the battery wire with one terminal of the bell, the other being put to earth. If the wire in the coils is continuous and the connections are perfect, the hammer will move, but if the wire is disconnected or broken, a current cannot flow, and the hammer will not be moved. To determine this fault, examine the connections of the coil wires with their screws ; these ought to be firmly, but not too tightly, screwed down ; if there is no fault in the connections, and a current will not flow, the wire in the coil must be broken. This is a case which very rarely happens. In the event of a breakage in the coil wires, or in the connections of the key, it will be well to have the repairs made by a proper instrument maker.

Frequent mention has been made of putting one wire to earth in testing. This can be done by completing the circuit with the battery by connecting the "earth" wire to the zinc pole and testing with the carbon, or vice-versa. If in testing, the coil wire is found to be continuous, any fault must be looked for in the

earth connection. Every bell may in this manner be tested and the fault located.

e.—To test a line wire for leakage caused through imperfect insulation—If at any point the insulation of the wire is imperfect, from being in contact with an inferior conductor, partial earth will be formed which will cause a weakening of the current, a portion of it leaving the wire for the earth, but if the conductor is a good one, then total earth will be made and no current will flow past that point. In order to test whether leakage exists, the galvanometer must be employed. Disconnect the line wire from every connection which leads to the earth, leaving the ends freely exposed in the air, and removed from walls of buildings, &c. Connect one end of the line wire with the galvanometer, the battery wire being also connected thereto; if the insulation is perfect the needle will remain unmoved, but if there is leakage the needle will be deflected, and the greater the leakage the greater the deflection, because the circuit will be completed, through such leakage, with the earth.

f.—Three, or more, bells are supposed to be worked in the one circuit. *a*—One bell will ring but the others are silent; *b*—Two bells will ring but the third is silent; *c*—None of the bells will ring. These three cases comprise the possible combination of faults in the system. The bell at the pit bottom will be called B, that on the pit head P, and the one in the engine house E. The bottomer we will suppose has transmitted a signal with his key, the bells B and P sound but E is silent, proving the existence of a fault between the line connections and the earth through E at a point somewhere beyond P. In giving a number of signals rapidly following each other, as the three strokes when men are to ascend or descend the shaft, one or more of such signals may be missed by one of the bells. This may imply a weakening of the current through exhaustion of the battery, leakage in the line wires, dirty connections, or corrosion of the wire connecting the faulty bell with the line wire. This is very apt to occur when the insulating material cracks by allowing dampness to enter and come in contact with the wire, and will generally be shewn on the outside by a green streak on the gutta-percha. In many cases when a bell ceases to sound properly, it is only necessary to

alter the adjusting screw one or two turns forward, which reduces the travel of the hammer and brings the armature nearer to the magnets, but if this fails the battery must be refreshed with chloride of ammonium solution.

Where there are many wires together, they ought to be numbered, and a record kept of such numbering, and every wire ought to have its proper position throughout the whole length ranged. Wires ought to be systematically put up, so that each one can be picked out at once.

It is essential that the battery is kept clean, and our practice is to have it examined, generally once a week or fortnight, when any incrustation or dirt is removed and the connections cleaned, the contact faces of the nuts rubbed once or twice on a fine file if they appear dull. A supply of zincs must be kept on hand as this element requires most frequent renewal. These can easily be made at the works by having iron moulds made to the size, a piece of copper wire being cast into the top of each one. To amalgamate these, mercury must be employed; it may either be rubbed on or the zincs dipped into it, the latter method being the most expeditious. Have a tube of sufficient diameter to let in the zinc bar easily and closed at one end; insert into this tube a quantity of mercury, and on the top of the mercury a mixture of sulphuric acid and water, one part of acid to three or four parts of water; pass the zinc bar through the acid (which will clean the surface) down into the mercury to the desired depth; the bar will then be amalgamated, and when dipped into water to remove the acid adhering to it, is ready for use. The copper connecting wire must be covered with tarred tape wound tightly round, it or tarred linen thread may be plaited thereon, or a piece of thin gutta-percha strip put on hot, as in jointing a wire, or anything which will preserve the copper wire from the ammoniacal fumes generated in the battery when in action.

An independent battery may be placed in connection with each key, but it is preferable to have the battery power centralised at one place, say in a corner of the engine-house where it will be kept warm and under more complete supervision, and defects thereon will be more promptly determined. It is a good plan to have the battery in duplicate, working each one for

a week alternately. By means of a switch either battery can be connected with the wire and the other one left at rest, and the only extra outlay would be the second wire in the shaft.

When the line, wires, and connections are properly fitted up, and the battery attended to, electric signals will work in a very satisfactory manner and cause no trouble, but bad material or workmanship in a very short time will be made manifest, and will cause great trouble and annoyance.

EXPLANATION OF DIAGRAMS.

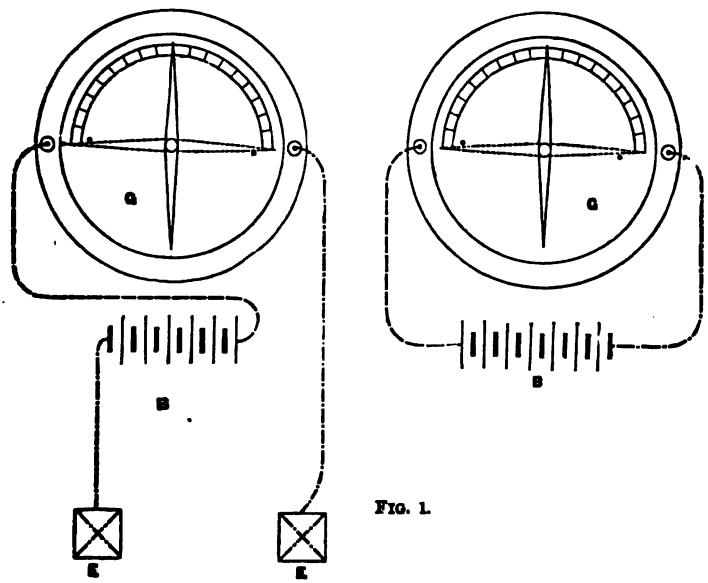


FIG. 1.

No. 1.—Testing a battery B, by means of a galvanometer A. In the first illustration the zinc pole of the battery and one terminal of the galvanometer are put separately to earth, and the wire from the carbon pole connected to the second terminal of the galvanometer. The second illustration shows the completion of the circuit through the galvanometer to the zinc pole without any

reference to an earth connection. The first system is the one adopted when testing a wire at a distance from the battery, the second when testing the battery alone.

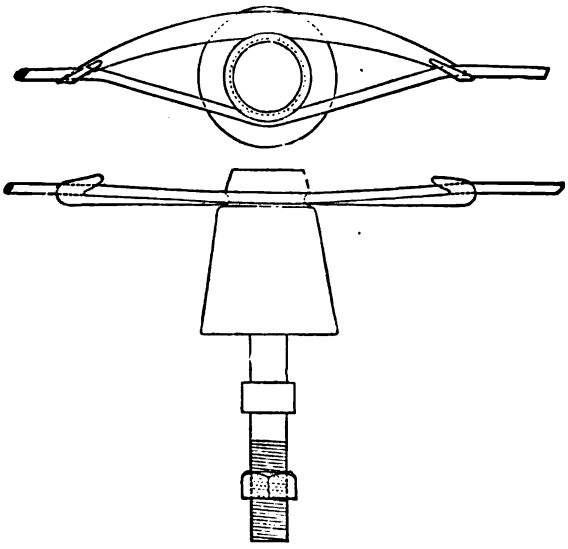


FIG. 2.

No. 2.—Sketch of E. Gilbert's method of attaching wires to insulators by means of iron bows which are used instead of binding wire, it also shows a common form of porcelain insulator.

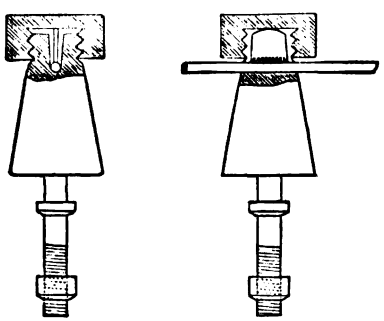


FIG. 3.

No. 3.—Represents Crighton's insulator securing the wire very efficiently by means of a screwed cap and serrated steel grips.

No. 4.—This shows the erection of an iron wire carried on insulators along the side of an underground road, and also the

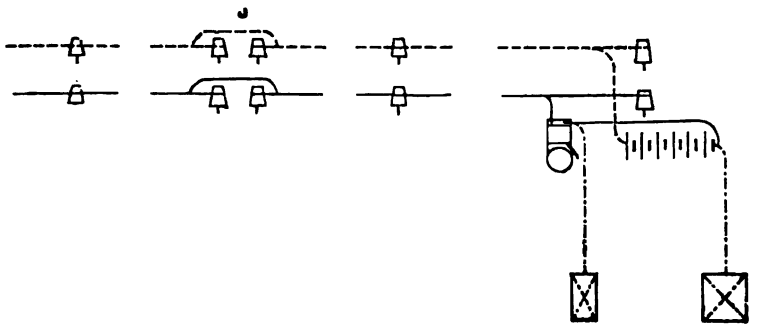


FIG. 4.

junction J made with a new length of wire to be ranged after the roadway has been driven beyond the innermost terminating insulator of the first line ranged.

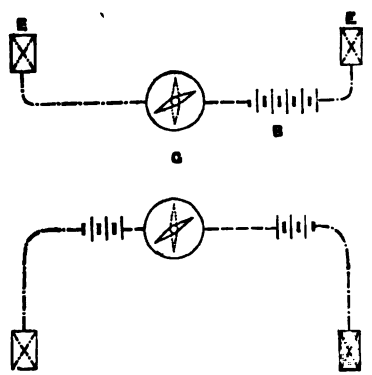


FIG. 5.

No. 5.—Arrangements of battery B, galvanometer G, and earth plates E, in the experiments noted before, representing the effect

of putting the carbon and zinc poles of a battery to earth, completing the circuit through a galvanometer; also an arrangement with two batteries having the zinc pole of each plate put to earth through plates of different metals, the full line drawing of the needle representing the deflection caused by the passage of a current, and the position shown by broken lines being the position the needle would stand at if no current was flowing between the poles of the battery or batteries—the needle in this latter case pointing to the zero of the scale.

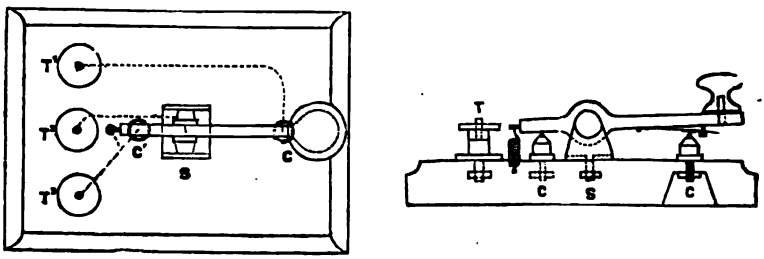


FIG. 6.

No. 6.—A form of signalling key referred to. T^1, T^2, T^3 are the three terminals, c the front, and c^1 the back contact pieces, the spiral spring being to the rear of c^1 which keeps the lever in contact with c^1, S, the centre support, carrying the lever. The internal connections between the terminals and contact pieces being shown in broken lines.

No. 7.—A system of signalling by means of keys from fixed stations only, in which B is the battery, K the key, and E the earth plate. In the first arrangement, a battery is placed in connection with each key; in the second, duplicate batteries are placed at some convenient and suitable point, a second wire being ranged to each station from which it is desired to transmit signals. The carbon poles of these batteries are connected to the plates 2 and 3, the line wire leading to the keys being attached to plate 1

of the Switch S. Each battery can thus be worked for a week or month at pleasure, and then switched off by means of plugging

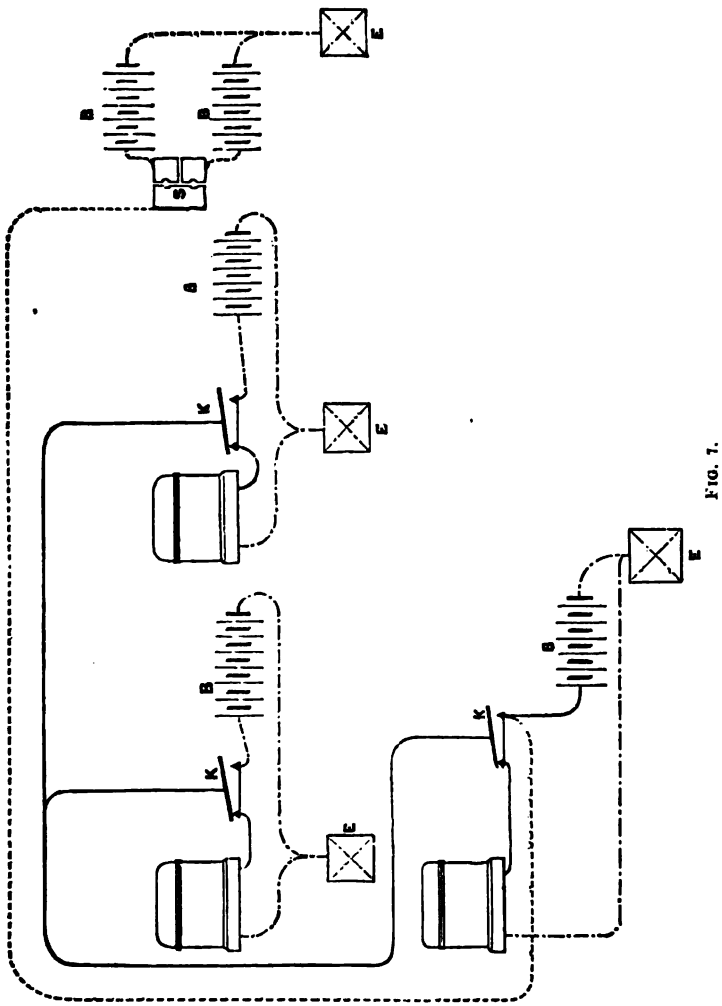


FIG. 7.

the hole H or H^a (see Fig. 9), and the duplicate battery brought into the circuit.

No. 8.—Illustrates a system of testing a line-wire for leakage. the earth-wires being disconnected from every bell, and the bat-

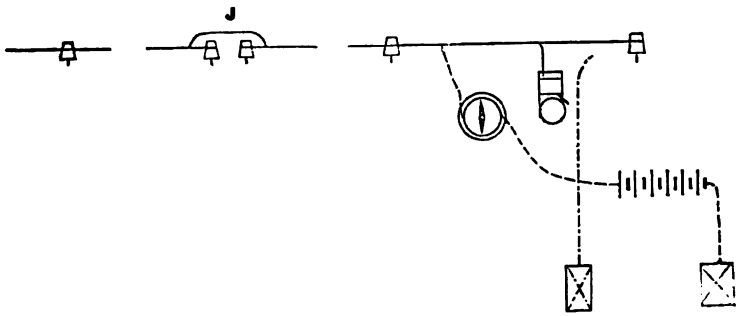


FIG. 8.

tery connected to one end of the line through the galvanometer.

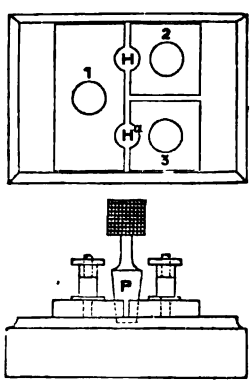


FIG. 9.

No. 9.—Plan of one form of switch, called the plug switch. This consists of three plates of brass firmly secured to an insulating board, and separated from each other about $\frac{1}{32}$in. or $\frac{1}{16}$ in.

Conical holes are bored through these plates to receive the plug P and which are shown at H H^a The plates 2 and 3 are connected with the carbon poles of the batteries, the third being connected to the line-wire. When the plug P is in the hole H, the plates 1 and 2 are in metallic contact, and the battery which is connected with plate 2 will be in circuit, but when the plug P is removed to hole H^a the first battery is cut out, and the second battery is brought into action.

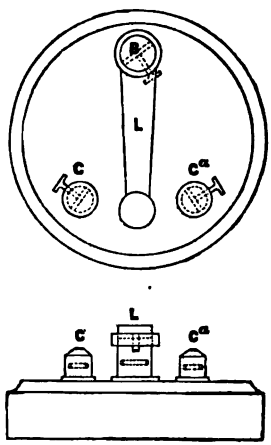


FIG. 9*a*.

No 9*a*.—This is a different form of switch, but acting in exactly the same manner as that previously mentioned. A brass lever is pivotted at B, upon which it is free to revolve, and from this pivot a wire is led to the line, the carbon poles of the batteries being connected to the contact pieces C and C*a*. When the lever L is on C, one battery is in circuit, but when L is removed to C*a*,

the first battery is cut out, and the second brought into connection with the line through the key.

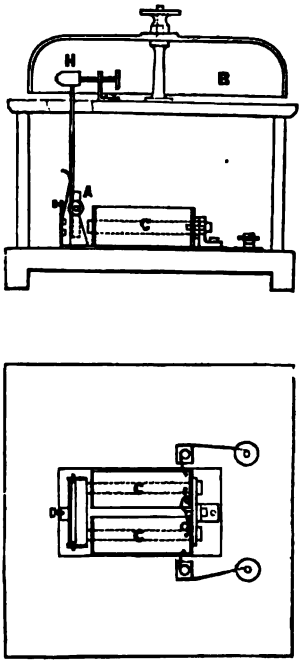


FIG. 10.

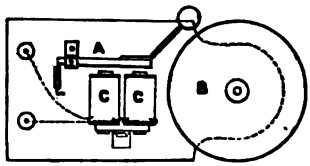


FIG. 10a.

Nos. 10 and 10*a* illustrate different forms of bells. No. 10 is intended to put on a table or shelf, whereas No. 10*a* is for hanging up on a wall. H is the hammer, C the coils, and A the armature. These bells can be either single stroke, *i.e.*, giving one stroke for each signal made, or vibrating, *i.e.*, they will continue to ring so long as the circuit is completed from the battery through the line-wire.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 9th JUNE, 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

J. M. Ronaldson, Esq., Vice-President, in the Chair.

Thirty-seven members were present at the meeting.

The Secretary read the minutes of the last General and Council Meetings; they were approved of and signed by the Chairman.

The following gentlemen were balloted for and admitted as Ordinary Members:—

JAMES BEVERIDGE, Colliery Manager, Loanhead, Edinburgh.
FRANCIS DANKS, Overman, Albyn Cottages, Broxburn.
ALEXANDER KENNEDY, Colliery Manager, Broxburn.
WALTER M'FARLANE, Colliery Manager, 12 Whitefield Road, Govan.
ARCHIBALD RUSSELL, Junior, Coalmaster, Roslin, Bothwell.
JOHN R. WILLIAMSON, Mining Engineer, 12 St Andrew Square, Edinburgh.

Other three gentlemen were then nominated for election, and will be balloted for at first meeting.

REPORT ON SMITH AND MOORE'S PATENT METHOD OF GETTING COAL.

BY MESSRS. BARROWMAN AND HASTIE.

"An improved method of, and apparatus for breaking down or getting coal and other minerals in mining, quarrying, or tunnelling operations" was patented in November, 1881, by Messrs Charles Sebastian Smith, land agent and solicitor, and Thomas Moore, colliery underviewer, and it has been carried on to a small extent in Shipley Colliery, near Derby.

Agreeably to your Council's instructions we visited Shipley Colliery on 19th April last, for the purpose of examining the method and reporting to you thereon. The patentees, who had previous notice of our visit, met us at the colliery, accompanied us underground, and gave all the explanations desired.

The system was seen in operation in one of the stalls of the Deep Hard seam in Woodside Pits, which are 118 fathoms in depth. The mode of working is longwall; the walls or stalls being from 90 to 100 yards in length, wrought on the "plane" of the coal and in a continuous line. The strata lie at a very slight inclination, and the workings are dry. The following is a section of the seam and adjacent beds:—

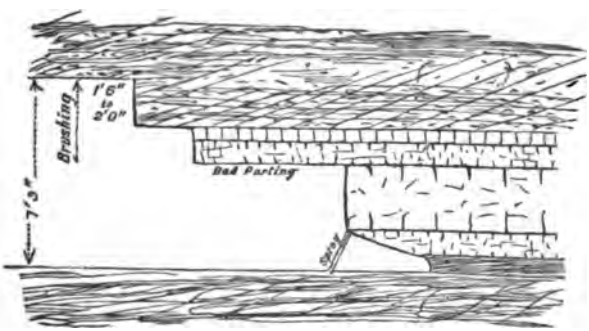


FIG. 1.

The coal, composing the marketable part of the seam, is hard and compact, with close but distinct "plane" joints, from 6 inches to 2 feet apart, and "end" joints few and irregular, the lumps

when broken up taking in consequence an oblong shape. There is not a regular parting between the good coal and the soft foul coal above it. The holing is made in the foul coal and fire-clay to a depth of 3½ feet, and sprags from 2 feet to 3 feet are put up, 6 feet apart, against the holed coal. In brushing—or ripping—the soft coal, the parrot coal, and from 1½ to 2 feet of the blaes are taken down, the roads being made 7 feet 3 inches in height. The road sides are built chiefly with the parrot coal. The rubbish turned over in the working—including the slack which is not put out—is not sufficient to fill the gob. Pack-walls, 5 feet thick and about 12 feet apart, are carried forward at right angles to the faces, as shewn on the sketch (fig. 2).

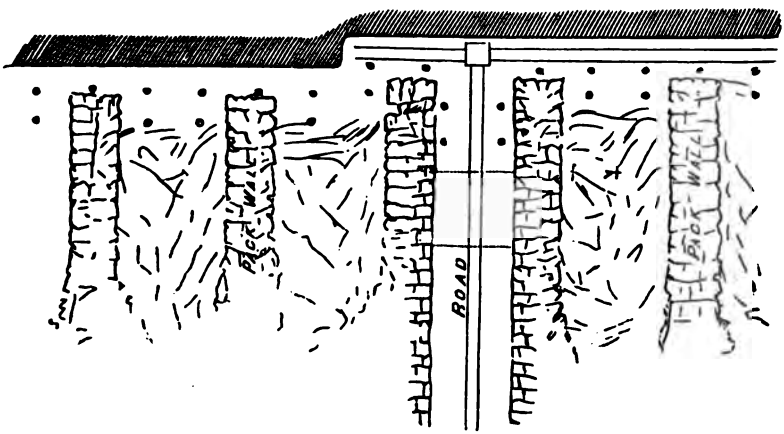


FIG. 2.
Scale—½ inch = 10 feet.

Two rows of trees, of 6 or 7-inch wood, 6 feet from each other, the rows being from 3 to 4 feet apart, are put up along the whole stall, and the row next the face is put up as close as convenient to the coal—usually from 2 to 3 feet before a new holing is begun. After the coal has been holed and dislodged by the patent method, it is broken up and filled in to the tubs, which are led on rails along the face. As each holing of coal is in process of removal, the props in the back row are taken out and put up next the new face of coal. Twenty men and boys are employed in each stall, 40 tons being the usual daily output.

Messrs Smith and Moore's patent consists in putting lime into a hole, and slaking it there, in a confined state, the steam given off and the subsequent swelling of the lime exercising a force which brings down the coal.

The coal face is prepared for the process in the following manner:—Holes, 3 inches in diameter, are drilled 3 feet into the foul coal immediately on the top of the good coal, a groove being cut in the foul coal roof to allow the drill to be applied. These holes are at right angles to the coal face, and are put in from 5 to 15 feet apart, according to the difficulty of bringing down the coal; the usual distance apart is 6 feet. The patentees informed us that they had found from practice that, as compared with gunpowder blasting, double the number of holes is required for the lime.

The lime before being used is prepared as follows:—Soft-burnt limeshells are ground into a powder and compressed in a die under a pressure of 38 tons into the form of a cylinder 4 inches long and 2½ inches in diameter, with a groove about three-quarters of an inch wide along its side. These cylinders of lime, called by the patentees "cartridges," are wrapped singly in paper and put up in quantities of four dozen in tin-lined, air-tight boxes, in which they are conveyed to the workings. We were informed that the cartridges thus enclosed kept good for four months.

The water which is to saturate the lime inside the hole is led there by means of a half-inch malleable iron pipe, eight inches or so longer than the depth of the hole, having a groove along its outside and a stop-cock at one end. Before the pipe is put into the hole its inner end is covered with a piece of calico or cotton rag tied on loosely. This pipe, which corresponds to the straw or fuse in a gunpowder shot, is put in along the top of the hole with the groove up. The lime cartridges are then stripped of their paper covering and put into the hole with the groove upwards also, so that the pipe shall lie in it. Seven cartridges are usually put into a three feet hole, each as it is put in being gently rammed so as to fill up the space. The requisite number having been put in, the remaining nine inches or so of the hole is stemmed in the usual way by hand. The outer end of the tube is then attached by means of a smooth, bevelled coupling to a half-inch flexible

pipe leading from a small force pump sixteen inches long with a one and a quarter inch bucket. The pump is not fixed to the pail containing the water, but attached to it is a stirrup or foot-hold by which it may be kept steady while the water is being pumped from the pail. The connection between the pump and the iron tube having been made and the stop-cock opened, water equal in bulk to the lime is forced into the hole and the stop-cock closed. The calico tied on the inner end of the tube is intended to prevent its being choked up by the sudden saturation of the lime there, and the water rushing through the tube appears to be checked by the calico, sent backwards along the groove on its outside, and dispersed through the lime along the whole length of the charge. Through the combination of the water and the lime, heat is rapidly generated and steam given off; and within two minutes from the time the water is put in a slight bursting sound is heard caused by the pent up steam. The pressure of the steam and the swelling of the lime continue the process of separating the coal from its bed—the bursting sound being heard till the lime is spent.

On the occasion of our visit to the stall where the system is in operation, we found twenty-five yards of the wall holed three and a half feet in, and sprags put up every six feet. Eleven holes had been drilled, charged with lime, and stemmed, and the boring machine was set up in readiness to drill the twelfth hole. The boring machine is one of simple construction and readily adaptable to different heights of workings; it is patented by Messrs Carr & Urwin, Scotswood-on-Tyne. It may be well to state at this point, that, although by the kindness of the patentees a complete set of the appliances used by Messrs Smith and Moore—including Carr & Urwin's patent drill—is exhibited at the reading of this report, yet no drawings of Messrs Smith and Moore's appliances will appear in the Transactions, as Mr Smith objects to drawings being published.

A three inch hole was drilled by one of the stallmen to a depth of three feet in seven minutes, and the filling and stemming of this, and the charging of it and the eleven others with water occupied twenty minutes more. Fifteen minutes thereafter the sprags were withdrawn and the whole of the coal affected by the

twelve holes—*i.e.*, between seventy and eighty feet in length and about three feet in breadth—fell, with the exception afterwards mentioned. The breadth of coal brought down appears to be sometimes more than three feet (the depth of the hole), as we observed that the former fall had been for several yards on the line of a plane joint six inches further in than the inner end of the holes. There was no appearance of the roof having been affected in any way.

One of the charges did not operate and the coal did not fall there when the sprags were withdrawn. It was seen that in that case the force of the charge in the holes on both sides broke the coal across the bed as shewn at *a* and *b* on sketch (Fig. 3)—

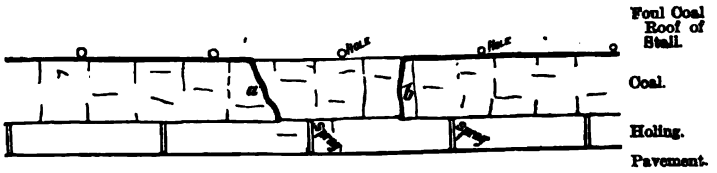


FIG. 3.

The reason for the failure of that particular charge was not clear; but it was suggested that the pipe had been thrust to the back of the hole and not drawn back an inch or so as it ought to have been, and that perhaps the water was thus prevented from getting vent.

With the exception of the slight bursting or "working" sound before referred to, the process is a quiet one, and it seems free of danger so long as the sprags are in.

There was no perceptible increase of temperature in the stall while the lime was operating, although the heat of the pipes, even outside the hole, was considerable, and the lime after the coal had fallen could scarcely be held in the hand. The lime could be smelt in the return air after the coal had fallen, but being still in a somewhat damp and consolidated state, it was not carried by the air current to such an extent as to cause inconvenience.

The lime of the exhausted charges, and of any cartridges that happened to be spoiled before being used, was thrown into the gob, no precautions being taken to prevent the possibility of com-

bustion of the coal or slack by coming into contact with the lime. We were informed that no burning had ever been observed; but, although the chances of such small quantities of lime causing combustion may be remote, especially in a dry working such as that at Shipley, yet it might not be safe to assume that combustion in every circumstance in which this method might be applied is impossible.

The lime whitens the coal a little at the boreholes, but we were informed that customers do not object to the coal on that account.

There is little or no regular issue of fire-damp in the workings of the Deep Hard seam, but outbursts have taken place at long intervals of time. About 25 years ago a serious explosion occurred, and blasting was thereafter prohibited. Since that time both the getting of the coal and the ripping of the roads have been done by wedging.

We had not an opportunity of comparing in a satisfactory way the lime process with the wedging, as the coal in the other stalls had been wedged down for the day, but the following is a statement prepared by the patentees, shewing from trials made by themselves the comparative results of the lime patent and wedging:—

COMPARATIVE RESULT OF LIME PATENT AND WEDGING AT SHIPLEY COLLIERIES.

DATE.	WEDGING. No. 2 Stall, Woodside Pits.		LIME PATENT. No. 1 Stall, Woodside Pits.	
1882.	Hours of Labour.	Tons got.	Hours of Labour.	Tons got.
Week ending Jan. 25,	96¾	225	58	274
Week ending Feb. 1,	100	178	71	236
Week ending Feb. 8,	123	225	90	258
	319¾	628	219	768

140 tons more coal got, with 100 hours less labour by the use of lime patent as compared with wedging.

On examination of that statement, it will be seen that the results in the different weeks by the same system vary widely; and, on that account, it may be questioned whether for extensive and continuous working a fair deduction can be drawn from these trials. It appeared to us, however, that the coal would be got by means of the lime patent with decidedly less exertion to the miner than by wedging.

As to the comparative cost of getting the coal by the lime patent and by wedging, we were informed that the miners who use the former are paid 2d a ton less than the others; but they are supplied with the cartridges and tools free, so that the 2d per ton does not represent the difference correctly. The cartridges had been made only on a small scale up to the date of our visit, and the cost of the process, as it would be in regular working, had not then been quite ascertained.

The difference in the proportion of large coal between the two methods was stated by the patentees to be one ton from each stall per day, or fully 2 per cent. in favour of the lime. We would expect such a result.

As to the applicability of the method to other seams and systems of working, we are not disposed to give a definite opinion, further than to state that we believe it will be to a great extent, if not quite, inoperative in an open-jointed seam; and it would, in our opinion, not be applicable, at least in its present form, in a wet working. On account of the slow action of the lime, as compared with gunpowder, the roof is not likely to be broken, and fewer accidents from falls at the face than presently occur might result from its use. It would perhaps be of advantage for the Institute to arrange with the patentees for a series of trials being made in some of the collieries in this district, in order to try the efficiency of the method, not only in long-wall workings but also in close work and "stooping" of pillar workings.

It has already been stated that the ripping of the blaes in the roads at Shipley was done by means of wedging. The patentees mentioned to us that they did not use the lime process for the ripping, on account of the difficulty of drilling holes in the blaes which is hard and mixed with ironstone balls. We are inclined

to the opinion that the power of displacement possessed by the lime is not great enough to render the method generally applicable to the blasting of rocks usually met with in mines.

JAMES BARROWMAN,
Mining Engineer, Hamilton.

JAMES HASTIE,
Manager, Greenfield Colliery, Hamilton.

The CHAIRMAN said the report would be discussed at another meeting, but if any one had any question to ask or remark to make at present it would be as well to hear it.

Mr AUSTINE said he was under the impression that a small committee should be appointed to experiment on the system in some of the collieries here. It was all very well to hear of it at a distance, and nothing could be more plain than the report, but it was better to see it as well as hear about it.

Mr ANDERSON thought it was stated that there were twenty men putting out about 40 tons in each stall. He thought that if that was all the system could do, it would be a question whether it would be worth while to have even an experiment. Judging from the nature of the holing and the thickness of the coal, he did not think it would be any great thing although that quantity had been put out without the aid of the caustic line by wedging it down or any other way.

Mr HASTIE explained that twenty men and boys did all the work, including brushing, setting props, and packing from the face to the point of main road.

Mr R. T. MOORE—And, I think, it is entirely round coal—not coal and dross.

Mr ANDERSON—There will not require to be any great extent of brushing with such a width of wall as 90 or 100 yards.

Mr HASTIE—The brushing is not a very great matter with such long walls, and the patentees only claim 2d per ton as the benefit from the patent.

Mr AUSTINE—That is a big profit now-a-days.

The CHAIRMAN—What about the round coal?

Mr HASTIE—They claim a little for that.

Mr BARROWMAN—I said fully 2 per cent.

Mr R. T. MOORE—What proportion of dross was got in the working?

Mr BARROWMAN—I cannot say definitely, but it will not be much under a tenth.

Mr DRINNAN asked if it could not be stated what proportion there was of boys and men. He approved greatly of what Mr Austine had suggested, viz., that there should be an experiment made in some of their coal fields here; indeed, at the last Council meeting he attended, he stated that he did not think it would be a complete report unless the deputation were prepared to give them some statistics with regard to how far the system would apply to the coalfields here. He understood there was some little difficulty in regard to the procuring of the necessary appliances, but he considered it would be worth while to incur some considerable expense in order to get the thing fairly tested in their own coalfields. Looking to the amount of coal they had to bring down at Shipley Colliery, he thought it would be well to test whether this could be done here without bringing down the roof. He knew at one colliery in England with which he was connected the roof was such that the workmen were not allowed to take out more than one sprag at a time. He thought the deputation should extend their labours and see how the system would apply to some of the coalfields of this neighbourhood.

Mr BARROWMAN said that according to his notes there were in the stall six or seven holers who holed by the yard, four contractors who drilled holes, built packwalls, put up props, and brushed the roads, two loaders, four lads who draw the coals in small trams along the face to the road head, and one loader-off—there being a double loading. That was only eighteen persons. Well, he believed, it was about twenty—sometimes more and sometimes less.

Mr DRINNAN—These loaders are at less wages?

Mr BARROWMAN—I believe so. With regard to the drawing of the sprags along the whole length of the stall, he did not think

that was their practice. They did it to let the deputation see the effect of the lime. Of course the roof was very good, and it might be possible there when not possible in other circumstances.

Mr HASTIE said he was of opinion that in a stoop-and-room working, with a roof such as they had at Shipley Colliery, they could bring down the coal with holes every six feet instead of twelve feet. It parted perfectly well, and there was an exceedingly good roof. But to try it with rock roof they could not bore their holes sufficiently straight.

Mr AUSTINE would be glad to give every opportunity for testing the system in the three seams—Ell, Main, and Splint coals—if the Institute desired. They could have the splint at Allanton and the other two at Cadzow. He was exceedingly anxious to see the system tried in stoop-and-room as well as in long-wall. It might have a different effect or none at all in a narrow room.

The CHAIRMAN thought they were much indebted to Mr Austine for giving them this opportunity for practically testing the system in the district. It appeared that Mr Birrell, Dunfermline, had arranged to try the system on his own account and in his own colliery with a friable coal, and the information they would get from Mr Birrell probably would be of much service to them in discussing the question.

Mr DRINNAN had understood from Mr Barrowman that he had been unable to make a satisfactory experiment simply because of the want of proper appliances. Did the same difficulty still exist?

Mr BARROWMAN said Mr Smith was willing that his system should be tried here provided his men were sent along with the appliances to work them. The Council did not feel disposed to be at the expense of bringing the men in the meantime until at least they heard the report. He had a letter from Mr Smith, in which he mentioned that he would soon be at Dunfermline.

Mr ANDERSON asked if the deputation themselves thought that this mode of bringing down the coal was applicable to stoop-and-room, for if they did not he thought this, coupled with the reluctance of the patentee to give any facilities for testing the process, did not look very well for it. At Auchinraith, they had had some experience of people giving out great things especially as regards coal-cutting machines, and most of them had been quite

willing to send a machine and their own men. He thought if those patentees were not willing to send the apparatus and the men at their own expense, it was not worth having.

Mr HASTIE—You do not require the patentees' men; you can make the experiments for yourselves.

Mr ROBERTSON asked if the patent lay in the machine or in the use of the lime?

Mr BARROWMAN—I believe the patent consists in the lime being in the compressed state, and in the way in which the water is introduced to the back of the hole.

Mr AUSTINE did not think any patentee would be so stupid as prevent anybody from making a fair trial of his patent. There was nothing to prevent anybody boring a hole, and they could make up lime cartridges and try them. He was prepared to risk it, and he thought it was in favour of the patentee if the experiments succeeded.

Mr ANDERSON asked if they would be inclined to pay the men's expenses coming down?

Mr AUSTINE—Certainly not.

Mr DRINNAN said the difficulty, he thought, with regard to the experiments made by them, was that it placed Mr Barrowman and Mr Hastie in rather a delicate position. They went and were afforded every facility in seeing the method, and it might be said now, if they were to commence and experiment here, that they were trading on the information furnished to them, and were making a base use of the facilities afforded them. On that account he was willing, even though there was a considerable expense, to pay the expenses of those men coming there. They all knew how patentees were very thin-skinned about their inventions, and had very magnificent ideas about them, and were very much frightened lest they got a bad name. They thought, too, it was impossible for anybody to understand it but themselves, and would not give anybody credit for understanding it although they explained it a dozen of times. He had no doubt they could do it, but they could not get the patentees to believe that; and seeing it would place them in a delicate position he would be inclined to pay whatever expenses would be necessary in order to have it tried.

Mr BARROWMAN—It is worth while mentioning that it is railway fares only.

Mr AUSTINE was under the impression they were quite able to carry out any experiments they wished without the assistance of the patentee. He could not conceive any two men going to see the operation and not able to carry it out, and he was inclined to think with Mr Anderson that if not worth being tried without their men here, he did not think it was worth much. He certainly would be for trying it without them.

Mr ANDERSON—I think we should not have anything to do with it.

Mr HASTIE—I would go the length Mr Austine goes, and give facilities for a trial, but I would not pay their expenses.

Mr SHARP, in order to test the power of displacement of the lime, asked if the coal was difficult to bring down by wedging?

Mr BARROWMAN said, as he had mentioned, they had not a very good opportunity of seeing the wedging; but judging from the state of the wedges and also from the small portion of the face that they saw the miners operating on, the wedging seemed to be very difficult. That considerable force was required to bring down the coal was shewn by the coal being broken across the bed on each side of the hole which failed.

It was finally resolved, on the suggestion of Mr Austine, to intimate to the patentees that they were prepared to give facilities to try the patent before a committee of the Institute, provided they sent down their men.

MR HOGG'S PAPER.

The CHAIRMAN having introduced the discussion on this paper,

The SECRETARY read the following communications :—

Mr W. S. RUSSELL—I may state my experience in the turf coal here. I drive two levels—a low one and a high one—and put all the branches off the high level. It is a good road and easily kept; but I have great difficulty in keeping the low level open as

the weight all comes down the hill and crushes and breaks the roof so much that I am obliged to brush all the splint coal that is left for a roof, and even then have great difficulty in keeping it with timber, but as long as it is kept open, it does for a water course. It might be as well to give a section of the coal and state the nature of roof and floor :—

	Ft.	In.
Hard Ironstone Rib, ...	1	0
Clay, ...	1	8
Splint Coal, ...	3	1
Blue Stone, ...	1	1
Breast Coal, ...	1	11
Blue Stone, ...	0	11
Bottom Coal, ...	1	10
Soft Daugh, ...	0	1
Pavement—Hard Fakey Rock,... ...	—	

I work out the turf coal long-wall, and take down all the stone in the working, leaving the splint coal for a roof and building it with the blue stone, daugh and dross from the coal, all of which is put into the building. The splint coal is worked out afterwards, either by beginning at the boundary and working to the shaft, or by working outwards to the boundary. I will try and give some notes regarding the taking out of the splint in the course of two months.

Mr JOHN ROBERTSON—My experience in taking out the whole of the coal from the pit bottom on the long-wall system is quite at variance with the remarks of Mr Dundas Simpson; but circumstances and the connections the coals have had, may have had something to do with it. The seam of coal I tried was 3 feet thick, with a very soft pavement, so that every tree required a sole. The roof, 4 inches of blaes, 6 feet of calmstone, then firmer fakes, making a fair roof, for the roads seldom required gearing. With this trial I was so satisfied that I had gone wrong, that I have never thought of trying it again. I had trouble, which means expense, with the pit bottom, gearing in the bye-roads, and lodgments, which had to be removed more than once. The pit barring and slides got twisted and required repairs for a considerable time. I can corroborate Mr Drinnan's opinion as to the leaving of pillars on main roads, so as to prevent the pressure from long-wall disturbing

them. I consider stooping to be as severe a test on the main road pillars as long-wall workings. I have stooping going on just now, and I take the stoops out to the main road pillar, which is 15 yards to the rise and 66 yards along the level road, and the main road does not appear to be affected. This pit is only 50 fathoms deep. The coal is 5 feet thick, and very hard, with a hard pavement and a calmstone roof, so it cuts itself off the stoop very quietly.

The CHAIRMAN asked if any gentleman had any remarks to make with regard to drawing prop-wood along the face of a long-wall working. They saw from the reports that in England they systematically did this. Had any gentleman any experience of this in Scotland?

Mr SMITH said that at Blantyre they took out all the sprags they could with safety in the "cundies." There were very few whole, but they got the most of them out. There are no props left in the buildings.

The CHAIRMAN—Do you take them out systematically, and put them up again according to the English system?

Mr SMITH—Yes. Those that are not broken are put up.

Mr DRINNAN—Would you state whether the props are drawn by the colliers, or by men specially appointed for the purpose?

Mr SMITH—The firemen draw them at the cundies, and the brusher at the buildings.

Mr MALCOLM said he had wrought in a place where they took out the props when they put up their face buildings.

The CHAIRMAN—And did it succeed well?

Mr MALCOLM—Yes.

Mr DRINNAN said in his opinion, and from all the experience he had had, he thought it could be less expensively done and quite as efficiently if the colliers were to do the work and the firemen were to see them do it. That had been his experience in connection with the taking out of the props, and not only the whole ones but the broken ones as well, which latter were cut up for short sprags and lids or anything that they could be made available for. It was the duty of the fireman to see that they were not buried in the pack walls, and it was very little trouble for the collier to do it.

The CHAIRMAN said, with regard to the use of old timber, a great deal semed to be lost through a little want of attention. The miners here had a great objection to this work, thinking they were endangering their lives, but in many cases the props could be withdrawn with comparative safety. He did not think this was a point they, as a rule, gave much attention to; in England they seemed to go far more systematically into it.

Mr HOGG, in summing up the discussion, said—At page 22 Mr Barrowman says shaft pillars may in some cases be dispensed with, and at page 36 Mr Simpson says he would take everything out, leaving no stoops whatever. At page 26 Mr Grant says that leaving no stoops was the cause of trouble at Bothwell Park. My opinion is that the system of leaving no stoops round pit bottom must be of limited application. To suppose a case where the ell coal is working by stoop-and-room method, and the Pyotshaw wanted to be wrought long-wall, would Mr Simpson leave no stoops round the pit bottom in the Pyotshaw seam? Other objections might be made; but those who have tried it in deep shafts are best able to say whether they would continue the practice or not. As to leaving stoops along main roads, there are cases where this may be done. For instance, where communications in upper seams have to be protected, &c. Unless for some such reason I would not have stoops anywhere but round the pit bottom. It is certainly a good thing to keep a low level going as a water-course if necessary, and practice has proved that the main level stands all the better for it. This low level may be useful also as an air-course.

On the motion of the CHAIRMAN, a cordial vote of thanks was given to Mr Hogg for his paper, and Mr Hogg briefly returned thanks.

THE SAFETY LAMP REPORT.

The CHAIRMAN, in inviting discussion on this report, said some of the gentlemen who were in the habit of using safety lamps might express their views as to the best in practical working.

Mr R. T. MOORE thought it was instructive to see that the two

lamps most used in Scotland—the gauze lamp and the naked light—were the two most expensive lamps of those examined by the committee. The extra cost of the gauze lamp was caused not only by the great outlay for repairs, but by its burning a large quantity of expensive oil. It was generally defended on the score of economy, but then evidently the cost of upkeep and oil was not taken into account when this defence was made. The cost of the oil burned by a lamp was frequently left out of account in deciding upon the kind to be employed, but it was seen from the table that the initial cost did not form such an important factor in the economy of the lamp as the kind of oil burned by it. From the details given of the costs it was seen that lamps burning spirit were much more economical than those burning oil, and they gave a much cleaner lamp.

Mr ROBSON said there was one point in regard to the use of safety-lamps which he thought ought to be brought out clearly, viz., the length of time they would burn without having to be trimmed at the "station" where a naked light only could be used. He did not think it was noticed in the report, but it was a point on which members generally might give their ideas.

Mr DRINNAN was not very familiar with any of those lamps except the Clanny, but it was unnecessary to take them back to be trimmed. The vessels held as much oil as would burn for an ordinary day, and they were furnished with a "picker" by which they could at any time trim the wick without being under the necessity of going to the station to have the lamp opened.

Mr ANDERSON had had some experience with the Clanny lamp for more than twenty years, and when they were starting at Auchenraith they were going to introduce it, but fortunately there was another lamp turned up called the Mueseler Protector, and they got the Clanny lamps taken back and had used the Mueseler ever since. He thought it was a very easy matter to get the Clanny lamp to burn as far as oil was concerned for a whole shift, but it was a very difficult matter to get a good light with it. At least, that was his experience. The picker could push or pull down the wick, but he never yet got into the system of properly taking the crust off it and leaving it in a good state for burning afterwards. With the Mueseler Protector, they got

it in the morning, went down the pit, were ten or twelve hours down, and they came up with it burning as brightly as when they went down. It needed no trimming whatever.

The CHAIRMAN had heard occasionally an objection urged against the Protector lamp, viz., that sometimes the sponge ceased to act and the naphtha would not serve the whole shift. Had any gentleman experienced that difficulty?

Mr DRINNAN must say, with regard to what Mr Anderson said about the Clanny lamp being difficult to trim, that his experience was different from his (the speaker's), and he was inclined to think there must have been something in the oil or the wick that caused the lamp in Mr Anderson's case to be difficult to trim, because, in a pit where over 300 men and boys were employed, he rarely saw a man come to have his lamp trimmed, and then invariably it was because something was wrong with the wick or the oil.

Mr AUSTINE might mention with regard to the Williamson lamp, so far as his opinion went in the use of them at Cadzow, it depended altogether on the men that used the lamp. They had men who went daily to the lamp trimmer; they had others who had never seen him. He thought it was entirely a matter of how they guided the lamp. He had seen one which had been under one man's protection for upwards of two years with the same glass, gauze, and everything, and they would fancy it was a new lamp, and this was simply because it had been well taken care of. Some young men, when they had not experience, and when the light did not give satisfaction, commenced to shake it up, and the result was they blackened all the glass, and the lamp going out they required to go to the trimmer. The man who understood the lamp never needed to do that, and the oil vessel, after being filled, would serve them for sixteen hours.

The SECRETARY entirely concurred with Mr Austine, that it depended a great deal on a man taking care of his own lamp. At Earnock they had both the Williamson and the Mueseler at work for a considerable time, and his experience as far as it went made him in favour of the Mueseler. The men liked it best. It appeared to require less care than the Williamson. There was another thing, too—the Williamson was more difficult to clean.

It required greater attention in cleaning; and he believed the lamp trimmer at first did not clean them properly and so did not give them a fair chance. Still, it was a fact that men, coming in the morning, and finding that someone had taken away their Mueseler lamps by mistake, and if Williamson's were handed to them, would as soon go away home as accept of the change. The men had been at him over and over again asking him to give them Mueseler lamps. However, as they had the Williamson, they required to use them. His opinion, moreover, was that the Mueseler, beside being easily cleaned, was certainly much cheaper as regarded daily upkeep.

The discussion was adjourned.

MR M'LAREN IRVINE'S PAPER.

The CHAIRMAN announced that although Mr Irvine was not present, the discussion on his paper would proceed.

Mr WILSON, referring to p. 59, did not think Mr Irvine was correct in saying there should be an earth-plate in the case of a metallic return. He understood it was only necessary in the case of a single wire. As to there being a distance of fifty or sixty yards between the insulators, he thought that was twice too much.

The SECRETARY said that, with No. 11 B.W.G., they found about fifteen yards sufficient; but if Mr Irvine referred to the wire of which a specimen was produced, he might carry it fifty or sixty yards.

Mr HASTIE said he had used electric signals for eight or nine years, and having two wires never knew what an earth plate was. He thought the writer of the paper had well stated the difficulties connected with such signals.

The CHAIRMAN said the paper seemed a most practical one. He thought those preparing papers for the Institute ought not to be debarred from entering into the elementary parts of their subject, because some members looked upon the Transactions as

a sort of dictionary, and he had no doubt if any of them were putting up electric signals and did not understand the subject the paper under discussion would be of very great assistance to them.

Mr JAMES YOUNG—Mr Chairman, allow me to draw attention to that paragraph on page 53, where the writer, referring to resistance coils, says:—"When resistance coils are attached to a galvanometer, the wire must not be wound on the bobbins in one continuous length, but half the length must be wound to the right, the other half being wound to the left, so that the course of the current way be reversed, which will prevent self-induction." Another way of winding the coil to prevent "self-induction," is that recommended by Deschanel and other writers, viz.:—to double the wire and then to wind the coil with double wire. This arrangement effectually prevents the coil from having or receiving any inductive influence on, or from, neigbouring conductors or magnets. In fact, the influence exerted or received by the two strands of the coil cancel one another. This seems to me to be a simpler and better plan than that suggested by the writer, because the bobbins can then be wound in one continuous length, so that there is not the same liability to error when winding.

The discussion was continued till next meeting, and on the motion of Mr BARROWMAN, the Secretary was requested to write the author of the paper and ask his presence at the meeting.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 13th JULY, 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Thirty-three members were present at the meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of, and signed by the President.

The following gentlemen were balloted for and admitted as Ordinary Members:—

JOHN ROSS, Benhar, Whitburn.
ROBERT COLQUHOUN, Westcraigs Colliery, Armadale.
JAMES BALLANTYNE, Woodend Colliery, Woodend, Bathgate.

Other two gentlemen were then nominated for election, and will be balloted for at first meeting.

The PRESIDENT said there was a communication from the American Institute of Engineers inviting the Institute to send a representative to their meeting at Denver in the Rocky Mountains. It was a pity it had not been a little earlier when he was there. As it was the Council had decided that there was no need

for sending any representative. Proceeding to refer to his American tour, the President said that since he had last been in the Institute he had been in the United States of America, and had had an opportunity of studying some of the resources of that great country.

Before starting he had made up his mind to be away ten weeks, and the plan chalked out by him was to visit some relatives in San Francisco; to visit some of the deep gold mines and examine the machinery; and lastly, to see some of the coal mines.

It seemed to him that the best mode of accomplishing this was on landing at New York to pass without delay to San Francisco, and then leisurely to fill up the rest of the programme in the return journey.

Following up this view he left Liverpool on the 6th of May in the Cunard Company's steamer "Scythia," and landed in New York on the 17th.

Leaving New York next day by the way of Albany, Buffalo, to Chicago and Ogden, and thence by the Central Pacific route to Sacramento and San Francisco, the journey occupying nine days' continuous travelling, he reached San Francisco on the morning of the 27th of May.

As far as Chicago there was a double line of rails, and the speed was about 38 miles an hour.

Chicago is a large city: it contains many fine stone buildings, and the streets are wide and well laid out. It is the centre of a large manufacturing and agricultural district, and the stir in the business streets reminds one of the stir in Argyle Street of Glasgow.

West of Chicago the line is single, and the speed is reduced to about 20 miles an hour, at which rate the train moved on continuously over the prairie lands, gradually reaching and crossing the Rocky Mountains and the Sierra Nevada Range, until San Francisco was reached. After leaving Chicago, the land became less cultivated and got gradually wilder and more sparsely populated. The farm houses, workmen's houses, and station houses along the line were all built of wood, plastered in the inside, and looked comfortable.

San Francisco is a large town, containing over 200,000 inhabitants, and is the principal city on the Pacific side. It contains some fine buildings and streets. Before the year 1849 it consisted of a few huts only, and now it has tramways, the electric light, and all the other adjuncts of civilization. The tramway cars are drawn by horses for the most part, but there are about ten miles of tramways through the principal streets in which the cars are drawn by wire rope haulage, like our ordinary rope haulage in mines, with this difference, that the rope, instead of being on the surface, is in a pipe under the roadway. This pipe has a slit along the top, and an arm from the car passes through it and catches hold of the rope. It is a very ingenious arrangement and works most satisfactorily. The speed is about five miles an hour.

The houses, for the most part, are built of wood, painted stone colour, and many of them are most costly structures. Inside they are plastered and finished like ordinary houses, some finely painted and papered.

There is a great danger from fire with so many wooden structures, and the fire engines require to be and are very complete. In certain parts of the city all new buildings must be of stone or brick.

With its excellent harbour, San Francisco is the port for steamers from China, Japan, Australia, and Panama.

A novel feature of San Francisco is the Chinese settlement, which is on the outskirts of the city, and which contains about 20,000 Chinese. These Chinese—for the most part males—are employed in shoemaking, tailoring, washing and such like work, and many are employed as labourers.

It is very curious to look into the shops of the Chinese and see them walking about in their native dresses and their shops arranged so differently from European ones.

They are generally esteemed a patient, hard-working body of men, and they work for very low wages.

For some cause or other the inhabitants of the State of California are averse to more Chinamen coming among them, and none are now permitted to land.

The gold diggings of 1849, which caused the immense rush of

population into California, are now almost wholly at an end. I saw the remains of one of these where I was informed there were 2000 voters in 1856. The depth of surface to the rock seemed to vary from eighteen inches to ten feet, and out of this alluvial cover large quantities of gold were got.

These surface diggings are now for the most part abandoned, unless by a few Chinamen who are re-washing what was left over by former miners.

The main operations for gold digging are those carried on by large companies by hydraulic diggings and by mining. In the hydraulic diggings water is brought from long distances by means of canals and pipes, the water issuing through a nozzle like that of a fire-engine, washing away the earth more cheaply than could be done by removing it by any other means.

The *debris* and water so removed run along a sluice, and the gold, owing to its higher specific gravity, falls into the crevices and is collected by amalgamating it with mercury. He did not see any of those operations.

This mode of gold mining is likely to be interfered with on account of the large amount of stones and debris which runs into the rivers, and which interfere with the agricultural operations. So much of the gravel and stones has been washed down the river at Sacramento, that the bed of the river, which was some feet below the level of the land, is now above it.

Gold is also mined extensively in many of the States. He visited the Comstock lode in Virginia City, in the State of Nevada, where the deepest mines are to be found.

The Comstock lode was discovered about the year 1857, and has been worked more or less since that time. Virginia City is partly built on the lode, and stands about 8000 feet above sea level. It yields silver and gold, and an enormous amount has been raised.

At first the workings were on the out-crop of the lode, which lies at an angle of 70°; but gradually deep mining became necessary, and there are now shafts 2,700 feet deep.

Some of the mines on this lode have been very successful, but this has not been always the case, and at the present they are at a lower ebb than they ever have been before.

He spent two days underground in these mines. Besides their great depth they are heavily watered, and the temperature varies from 100 to 135 deg. F. These difficulties have called forth the energies of the very best mining engineers, and the result is that there has been an amount of originality and boldness in the designs of the machinery and arrangements for overcoming these difficulties which he had never seen surpassed. He gave two instances shewing this. A pumping engine of exactly the same dimensions as the Lesmahagow pumping engine, 60 inch and 100 inch compound, but to work at 100 lbs. pressure on the square inch, was sent out from this country. It was made by Mr Barclay of Kilmarnock, and constructed as best he could. The superintendent engineer, Mr Paton, conceived that it would be more suitable for their purposes if it were converted into a rotary engine, and forthwith it was dismantled, the cylinders inverted, a flywheel of 40 feet diameter and 50 tons weight was attached, the beam put under the cylinder and hung from the centre instead of the one end, and the whole of the hand gearing rearranged. He saw this engine so converted working steadily—with 2,500 feet of rods upon it. It certainly was working very well, and was said to be working economically.

It seemed to him that it would have worked well enough as Mr Barclay designed it. He merely mentioned the circumstance to show the daring of the engineers in carrying out their own particular views for making a steady work in the shaft and for saving fuel, which is a most important item in that country.

Again, in the Chollar, Norcross, and Savage mines, the machinery was found unequal to draining the water. The extra quantity to be raised was 1600 gallons per minute, and it was found that the weight of rods and moving mass was so great that the speed of the pump would be very slow, and thus the pumps in the shaft would be correspondingly large. Mr Requa, the superintendent of the mines, therefore adopted a plan proposed by the Risdon Iron Company to erect a hydraulic engine underground, which would work at 1000lbs. pressure on the square inch and discharge this quantity of water.

This gigantic arrangement, perhaps one of the largest in the

world, has been carried out, and he saw it working with the utmost smoothness, and discharging 1600 gallons per minute.

There are two hydraulic engines placed side and side, but independent of each other; each engine consisting of four plungers (two at each end), 6½ inches diameter, and 10-feet stroke, connected to a crosshead, which has suitable arrangements for opening and shutting the pressure valves, so as to give the necessary reciprocating motion. Between each pair of pressure plungers, and attached to the same crosshead, is a 14-inch plunger, and these force the water 813 feet up to the Sutro Tunnel, which is a tunnel driven into the hills from the surface at a lower level and drains the district. The other engine is precisely the same. All the four plungers discharge into the same rising column.

The water which supplies these engines comes from the surface, 100 feet above the top of the pit, and, after doing its work, is discharged into the Sutro tunnel. The power, therefore, is the difference of pressure between the head of water, 2500 feet, and the Sutro tunnel, 813 feet.

In the event of the Company failing to take advantage of the surface supply of water, there is a steam engine placed upon the surface for supplying power to the hydraulic engines.

This is a compound engine, driven by Davy's Motion (no flywheels), cylinders 35 inches and 70 inches, and 10-feet stroke, which works from the crosshead, four plungers 8½ inches diameter. These pumps force the water through an 8-inch pipe to an air-vessel 25 inches diameter and 70 feet high, and from thence down the shaft to the hydraulic engines, the exhaust water from these engines being returned to the receiving tank on the surface through 10-inch pipes, to be again pumped down the mine.

The machinery on the Comstock mines is all of the most modern kind, every precaution being taken to save fuel.

The shafts are all rectangular, and are fitted with cages and all the modern improvements. In one shaft he saw an automatic arrangement for emptying tubs direct from the cage, similar to that which he afterwards saw in Pennsylvania.

The erections on the surface—engines, &c.—were all very com-

plete and kept tidy; everything, including pithead frame and pulleys, were all covered over with a wooden roof.

Underground the arrangements are on a large scale. The workings are the same as in ordinary metalliferous mines, with levels every 100 feet. These levels are 7 and 8 feet high, and correspondingly wide. Rock drills, driven by compressed air, are used wherever possible.

In a lode 18 feet wide, frame timbers, 14 inches square, were carried up every six feet. These timbers are cut and fitted on the surface, and then brought down, and the vertical props set one upon another all the way up. The vein in some instances has been as much as 150 feet wide, and in this case the timbering was supported by being filled up with rubbish either brought from the surface or from mines driven in the rock on each side of the lode for that purpose.

Fuel is a most expensive item in this district, there being no coal available, and the boilers are all fired with wood. The wood is brought from a distance of 30 or 40 miles, partly by railway and partly by a contrivance called a flume, which is a triangular shaped trough set at a grade and partly filled with water. The logs of wood are put into this and floated down by the water. In some instances these wood flumes are 40 miles in length and form a cheap mode of conveyance.

There was not anything else very remarkable in the mode of working. One very simple thing was observed in firing shots. A clock is used to see how long it takes to go off. Every one knows how in that operation a minute sometimes appeared ten; but here was a very simple way by which the time could be ascertained exactly. On the surface, there was a very good arrangement of baths where the men changed their clothes, washed, and cooled off, previous to going home. The miners were a very fine set of men, mostly young fellows, which was accounted for by the fact that the whole region had been opened since the year 1860.

The diamond drill is used for driving lateral bores, and so saving the cost of driving expensive driftings to test the quality of material at the points sought for.

In some instances these bores reach 200 and 250 feet. All

machinery underground is worked by means of air engines, the pressure being supplied by air-compressing engines placed on the surface.

The heat varies from 100° up to 135°, and the water, which is frequently found in pockets, issues at 160°. The ventilation is by fans, some of which are placed in the mine and some on the surface. He saw one Guibal fan 20 feet diameter.

The miners are liberally supplied with ice, and drink iced water freely, without feeling any injurious results.

He did not propose to deviate much from mining, but he might remark that on one of his excursions from San Francisco, he passed through one of the groves of big trees. These trees are a kind of pine tree, and rise straight up for from 250 to 300 feet, and are from 25 to 30 feet in diameter.

One of them, a stump, 120 feet high and 31 feet in diameter, has a large hole cut through it. The road is carried through this opening, and the passenger coach, drawn by six horses, passes through it the same way as the omnibuses used to pass through Temple Bar in London.

The coal deposits of the United States far exceed those of any other country in the world. It contains coals of all qualities, and suitable for all manufacturing and domestic purposes, and no doubt they will play an important part in the development and prosperity of the country. At present the output is not more than one-third that of Great Britain, but it is extending very rapidly.

There could be no doubt but that the immense country he passed through had immense resources in minerals, not only in gold and silver, but in coal and iron. It contained all the elements of greatness, and probably in the course of forty or fifty years—some of them might live to see it—the produce of minerals in America would very far exceed anything in England. The railways were running in all directions; all that was wanted was men—not very much money, because it would very soon become a wealthy country.

Coming across home again, he called at Denver, which was an amazing place—a place of 60,000 inhabitants, which had all been raised within ten or fifteen years. It formed a sort of nucleus for

supplies for the silver and gold mines. The silver mines were reputed to be of great wealth. He did not see any and could not speak, but he was told of a very fortunate man. Here sometimes they had men who were fond of prospecting for minerals, but there it was a trade, and as a rule, like most others, the prospectors did not make much of it. They were generally poor. Sometimes they did make a hit. In one instance at Denver, he was told of two who had made something. The practice was, when they were very hard up, to get what was called a "grub stake," under which a grocer agreed to supply provisions while the men were out prospecting, and shared in the results. In this particular instance the "grub stake" was to have the half of whatever was found, and the prospectors each a fourth. Well, they did strike within fifty or one hundred miles of Denver a silver mine, which was sold for £100,000, of which the "grub stake" got £50,000 and the others £25,000 each. That was one prize, but generally speaking there were more blanks than prizes.

There are coal mines in Colorado; but he did not visit them.

According to the Industrial Statistics of Pennsylvania for 1879-80, the output of coal in the United States in 1878 was 49,130,584 tons, whereof Pennsylvania supplied over 31 millions.

He found he was unable during his limited stay to examine into the ironmaking industries, or to take both the Bituminous and the Anthracite Collieries. He therefore determined to visit the Anthracite regions of Pennsylvania.

According to the tables quoted above, the amount of Anthracite still to be mined in Pennsylvania is over 26,361 millions of tons, and the output in 1880 was nearly 23½ millions of tons; it has increased very rapidly.

In 1820	it was	365 tons.
„ 1830	„	174,734 tons.
„ 1850	„	3,358,899 tons.
„ 1860	„	8,513,123 tons.
„ 1870	„	15,849,899 tons.
„ 1880	„	23,437,242 tons.

There are about 340 collieries, producing, annually, about 60,000 tons of coal each.

The monopoly of the Anthracite Collieries is held by some seven corporations, who mine, sell, and transport their own coal.

Foremost amongst these is the Philadelphia and Reading Railroad Company, who, in the year 1881, raised from their own mining lands nearly 5½ million tons, and thus secured the carriage of them—much in the same way as if the Caledonian Railway Company were the lessees or owners of all the Hamilton coal fields, and thus secured a monopoly of the carriage.

He descended four collieries in the Shenandoah Valley, besides examining some in Pottsville.

The State of Pennsylvania has Inspectors of Mines, whose duties are much the same as those here. The Mines' Act is very much like ours—indeed is founded upon it. The Inspectors of the districts around Pottsville and Shenandoah are Mr Gay and Mr Mauchline, the latter a native of Larkhall, to whom and to Mr Foster, the Editor of the Mining Journal there, he was much indebted for many attentions.

The coal field is much contorted, and a cross-section bears a striking resemblance to the Belgian coal field. There are a number of seams from 3 feet and upwards, but the only seam which he saw working was the Mammoth Vein, which varies from 25 to 40 feet in thickness—not all one seam, but divided by various partings.

The dip and rise varies from flat up to 70 degrees, or nearly vertical.

In nearly all cases where there is any dip upon it, it is worked from the rise to the dip, the incline being driven down about 100 yards, and levels broken off each way, out of which rooms are broken 30 feet wide, leaving 30 feet of a stoop.

These levels are driven 11 or 12 feet wide, and 10 feet high, commencing in the pavement, leaving on all the coal above, and these require, in general, to be strongly timbered with 12 or 14 inch wood, on the Welsh plan, narrower at the top than at the bottom.

The rooms, or "breasts," are not broken off the level at 30 feet wide, but two narrow 6 feet by 5 places, with a pillar 18 feet between them are started, and these are joined together when they are 10 yards up, thus formi g the 30 feet wide breast.

These narrow places are driven at such a height in the seam that the pavement is level with the top of the waggon, and so allows the coal to slide down into it.

The room or breast then starts up hill, the miners taking 15 feet of coal from the pavement before them. The coal is of a hard nature, and requires to be blasted, there being no attempt at holing or shearing.

All the coals are allowed to lie until the room is up its distance, except so much as is required to keep the face clear. By this means the miners get working without the use of scaffolding, and the roof is supported, for they do not attempt to set up any props in the breast.

After the destination has been reached, the coals are allowed to slide down into the waggons, and the breast emptied.

There is a man-way carried up on each side of the breast. These are formed by props placed six feet back from the side diagonally to the side, about 5 feet high, and are cleaded with wood for the coal to slide upon.

The men go up and down these gangways to their work; there are also throughers put through for ventilation.

After the breast has been worked out, robbing the pillars and getting down the remainder of the coal is tried. So far as he could understand, the mode was to thin the pillars so much that the upper part of the coal fell down. The roof is a very good one, and so they manage to get a considerable portion of the coal. There must be a great loss. They admitted that not more than 50 to 60 per cent. was got, and thought it would not pay to attempt to take out more.

From the nature of the field, the coal has been first worked from the surface by means of inclines, so that even now there are more inclines from the surface than pits. The same reason may account for the large waggons or cars, as they call them, holding from 2½ to 3½ tons. As will be noticed, these waggons simply run on the levels, and are drawn up the slopes or shafts, as the case may be, but they are not taken up hill in the workings.

Mules are used for hauling along the levels, and occasionally locomotives are used for the same purpose. There is no smoke

from the coal, and it is found that 20,000 cubic feet of air passing along the gallery is sufficient to ventilate it.

In some cases they use "gunboats" on the inclines. These are waggons, holding from 5 to 8 tons of coal, and they are filled by emptying the hutch into them at the bottom of the incline. These gunboats empty themselves when they reach the surface, and the coal runs down into the screens for separation. In general all the loads coming up, whether on the incline or on the cages, empty themselves by an ingenious arrangement, which he hoped to be able to explain by a drawing at a future meeting.

The ventilation of the mines so far as he saw was moderately good. Some of them gave off gas, and one pit he saw was on safety lamps.

The mines did not appear to be heavy watered, and there were no heavy pumping engines. Special pumps appeared to be frequently used.

In blasting he noticed that instead of a needle they had a hollow tube of about $\frac{1}{4}$in. diameter, which worked very well.

The shafts were all rectangular and well constructed. In order to admit such large cages they were very large, and the winding engines were strong, but he saw nothing wonderful in the machinery. The deepest pit was that at Pottsville, which was 1600ft. deep. The boilers were all of the one pattern, about 30 feet long by 30 inches diameter, and pressed to 80lbs. on the square inch. The ends of these boilers were of cast-iron, one end contained the manhole door, and the other the steam and feed-water pipes.

The ends were not built in, they were fired at the bottom, and had the ordinary flash flues.

The coal gave no smoke, required a good draught, and gave off a great heat. In the furnace they burnt only the small dust.

The coal comes up to the surface all mixed, large and small, and pretty much mixed with stone.

In order to meet the requirements of the market, the large coal is partly broken up by teethed wheels, called breakers, and by a series of screens and elevators, and hand pickers, the

coal is divided into the following varieties. In a gross drawing of 300 cars, there will be

			Worth per Ton.	
50	Cars	Lumps, used in Ironworks, ...	2.10	Dollars.
35	,,	Boat Coal, those passing over bars 4 inches apart, used for Steamers, ...	2.10	,,
32	,,	Broken, passing over 3 inch bars, used in Blast Furnaces, ...	2.15	,,
23	,,	Egg Do., 2½ used do., ...	2.20	,,
13	,,	Large Stove Coal, passing over 2 inch screen, used for Stoves, ...	2.25	,,
15	,,	Stove Coal, passing over 1¾ inch mesh, used for domestic purposes, ...	2.25	,,
12	,,	Chestnuts, 1¼ to 1⅝ inch, do., ...	2.20	,,
20	,,	Pea and Buck Wheat, from ⅞ to ¼ inch,... ...	1.10	,,
100	,,	Refuse, partly used for firing boilers and for locomotives about the collieries, the rest, by far the greater portion, is run into the dirt bing.		

The number of men and boys on the surface engaged in this is almost equal to the number of persons underground.

He saw some Scotchmen, not very many, a good many Germans and Welshmen, a good many Irish—not so many as he would have thought, but the workings were hazardous, and required a good class of men. There was another thing. While walking through a mining town of 13,000 inhabitants, something like Wishaw, on a Saturday night, he saw the miners well clad, and he did not see a single drunk man. (Applause.) That was on a pay night, and he thought it was highly creditable. He had had the pleasure of attending a meeting of a kindred society in Pennsylvania which exchanged papers with this Institute. It was a small institute that had, like their own, risen from small beginnings, but by and by it would be something very important. He had the pleasure of telling them of their own small beginning, and how they were going on, and how they were to keep up their hearts, as it would not be for want of money but of papers if they did not succeed. They had deputed him to say how much they were pleased with the papers of this Institute. (Applause.)

In all his mining excursions he met with the greatest kindness and courtesy from the gentlemen connected with the mines, and no one going across the Atlantic on a similar errand need fail to obtain all the information he wants.

In New York there is a tunnel being made between New Jersey and that city. It will be upwards of a mile long, and will be used for connecting the railway systems. It is being driven within 30 feet of the bottom of the river, and in mud, the men at the face working in air compressed to 38lbs. to the square inch. They work 8 hour shifts, and do not seem to suffer from this pressure. Already the tunnel is 1000 feet in on the Jersey side, and is being pushed forward at about 3 feet per day. The finished tunnel is about 18 feet in diameter, the brick arching being 30 inches thick, outside of which is a malleable iron casing. The mode of procedure is thus—First a tunnel, called a pilot tunnel, 7 feet diameter, is pushed about 40 feet ahead, It is lined with malleable iron plates, on to which are bolted angle irons for bolting the plates together. The large tunnel is then cleared cautiously, and lined with plates 2 feet broad, having angle irons for bolting them together; these pieces as they are put in are stayed from the pilot tunnel in the same way as the spokes of a wheel radiate from the nave. After 12 feet has been thus taken out the brick arching is put in and the process continued as before.

Another novelty which he saw was the elevated railways which he can best describe by asking them to fancy each lamp-post in Argyle Street to give support to two girders, carrying a line of railway at the level of the first storey. These railways are a great convenience, but no doubt they destroy the amenity of the shops.

DISCUSSION OF THE REPORT BY THE SAFETY LAMP COMMITTEE.

On the PRESIDENT inviting discussion on this subject,

Mr DIXON said he wished to draw attention to the great disparity in the upkeep of the lamps reported on, and more particularly between the Mueseler Protector in use at Backmuir compared with the rest. In looking into the thing, he thought the basis could scarcely be the same. If they took the Williamson at Cadzow, they assumed apparently 1d per day as the cost

of trimming, wages and repairs, or 25s per year, while at Backmuir the Mueseler only cost 9s 10d a year. He would like to ask Mr Beith and Mr Bishop—Mr Bishop more especially—if this 1d was a mere assumption or the ascertained sum?

Mr BISHOP—It is not assumed; it is the result of actual practice.

Mr BEITH—The 9s 10d is the actual cost in our case also.

Mr DIXON—The argument is, then, that the Mueseler is by far the best lamp?

The PRESIDENT—The one is using naphtha and the other oil.

Mr BISHOP—That is where the difference comes in, the cost of naphtha being 8d and of oil 2s 8d per gallon.

The PRESIDENT said it must be seen what an immense saving there was between safety lamps and naked lights. They would also see that while the light given by a Mueseler lamp was 1 that from the naked lamp was only 1·24, the difference being very little. This led them to think that the common lamp might be immensely improved in some way or other, so that more light would be got from it at less cost.

Mr BEITH said that last night the Secretary in his remarks, p. 98, made reference to the Mueseler, comparing it with the Williamson. Was it the Mueseler Protector or the Mueseler alone he referred to?

The SECRETARY—The Mueseler Protector.

The PRESIDENT said if there were no other remarks on this very valuable report they must close the discussion at this time. It had gone over ground which, so far as he knew, had never been covered before. He would have liked an additional column giving the percentage of superiority of the best lamp in point of cost over the others. He thought the least they could do was to thank the committee for their report.

DISCUSSION OF MR C. M'LAREN IRVINE'S PAPER ON ELECTRIC SIGNALS.

THE President, in introducing the discussion on this paper, regretted he had not had time to read it. He might say that in America they adopted the electric signalling to a greater extent than they did here. They had, for example, a speaking tube from the bottom of the slope to the engine-house, formed of a 2-inch malleable iron pipe, and it acted admirably. In some cases they had a telephone worked by electricity, and in other cases the electric signals into the engine-house.

Mr DIXON thought Mr Irvine deserved the gratitude of the members for his paper. He might state that had this paper been put into his hands some years ago, he would have read and studied it with very great interest, for they were then fitting electric signals up at Bent. They had a great deal of trouble, and if any of the members had the same experience to go through he would commend Mr Irvine's paper to them. At Bent they were nearly giving them up in disgust; in fact, it was because the electric signals really could not be done without that they had to persevere until they got them to succeed. This paper pointed out all the difficulties which required to be overcome. He thought Mr Irvine's plan of having a galvanometer to detect flaws a very good one. They had not thought of this, but had a small bell, and used that for the purpose. When anything was wrong, this bell gave an indication as to where the flaw lay. They tried it on one cell after another until they got the whole to work. They found the great thing was to keep the cells clean, and give them proper attention. He would like to ask Mr Irvine if he still had the signals working in the shaft from the bottom to the engine-room, and if he found them to work without intermission. He might say that at Bent they began by having an insulated wire down the shaft, and having a bell in the engine-house on the surface, but this wire gave so much trouble that they took it out and put the bell in the bottom.

Mr IRVINE said that at present at Fence they had the signals only in the shaft, not in the workings. They found it necessary to

protect the wire to guard against the action of the air and the water on the gutta-percha so that it should not get hard. The great drawback was its cracking from exposure to the air.

Mr DIXON said that was what went wrong with theirs ; the gutta-percha cracked by the water.

Mr BISHOP, referring to p. 51, did not agree with Mr Irvine's statement that the sesqui-oxide would gradually absorb oxygen. and be reconverted back to the binoxide. He rather thought that the action that takes place when the cells are steeped in water for some time is to dissolve out the crystals of chloride of zinc which are formed in the pores of the porous cell when the solution of chloride of ammonium becomes saturated with chloride of zinc. Again, as regarded a statement at p. 58, about best sort of insulator. In practice they had found the cup insulator not so suitable or simple as a cylinder with a single groove. In the cup insulator, where the wires are put vertically one above another, the sag or dip of each wire is apt to become unequal, and the wires touch each other. In cylinder insulators two are used, one for each wire, but both strung on a single wood screw to the trees. As to the insulators being placed about 50 or 60 yards apart, that distance is much too great. About 10 to 15 yards is far enough ; it should be even less going round a turn. At Cadzow, when we started electric signalling, we found it required a great deal of attention to keep such a number of cells in thorough working order as were required to send the current to the extreme end of the lines, and we had fitted up what we called relays, such as are in use in cable telegraphy, and find the use of them to be a great advantage. Instead of nine to a dozen cells formerly required for each line, two are now quite sufficient for the work. The principle in which we use the relay is that two currents of electricity are used—a very weak one having a long distance to travel round the workings, and little work to do ; a second current, which does the work of ringing the bell, and not requiring to travel more than a foot or two, if necessary.

Mr IRVINE said oxidation did take place partially, but not to a very great extent, as he had just proved. Their battery was one of sixteen cells, and he tried sixteen cell centres which had been

exhausted two years before, but they failed to work the three bells. He attached other ten, making twenty-six in all, and they worked very well for 85 days and then ceased working. In respect of the insulator, it seemed to be a very neat thing if fitted up.

Mr BISHOP—The main wire is rolled round the insulator, or bound with binding wire in the usual way.

Mr IRVINE—Suppose it breaks, you must have it attached in some way? Every insulator of course opened a path to the earth, and caused a loss by leakage, so the more they could be reduced the better. Of course by working with relays a very weak current would work the relay, but they must have a battery for each bell, and the multiplication of batteries was a nuisance. He would rather concentrate the batteries in one place and work a stronger current.

Mr BISHOP said the wire was fixed on to the insulator, rolled perhaps two turns, and if a breakage took place it did not run back. They did not roll them round every insulator but every stoop length or so. Therefore, if a breakage did take place, they had only a stoop length to deal with. By working with relays the insulation did not require to be nearly so complete.

Mr HOGG, referring to the use of wires in the shaft, said that at North Motherwell they had had them for the last two years in a very wet shaft without trouble. The wires were taken through a half-inch pipe. They had never needed to examine them.

The SECRETARY would like to draw Mr Irvine's attention to Mr Hastie's remarks at last meeting, p. 99. Mr Hastie said he had used electric signals for eight or nine years, and never knew what an earth plate was. At Earnock they had fitted up electric signals, and he was in the same position as Mr Hastie—he did not know what an earth plate was. They were also forced to try the relays mentioned by Mr Bishop, and found them a great benefit. It seemed a little more complicated to fit them up, but by a little study was perfectly clear. Before they introduced them they had nine cells; now, they had extended the original wire a third of the distance, and were working with five cells, two of which were between the relay and the bell, but this was owing to the distance the bell was from the battery; for,

had it been nearer the battery, a single cell would have done perfectly well. Did Mr Irvine think that earth plates gave any better action than they would otherwise have?

Mr IRVINE said they saved a return wire only.

The SECRETARY—If you require a signal from any part of the road, earth plates are of no service?

Mr IRVINE said their use was in connection with single currents. They were not needed where there were two wires.

Mr DIXON said he did not know whether or not it was the general experience, but at Bent the wires after standing for a time, did not require insulation, so much as people would imagine, they got so coated with dirt that even though they touched the sides it did not do any harm. In fact, they had sometimes to take a knife and scrape the dirt off before they acted.

The SECRETARY said it was also their experience, in the inside and at the bottom, where the signals are mostly given, the wires require to be cleaned regularly, and they could not make so distinct a signal along the plane as in the inside or at the bottom. They had a great difficulty at first with the batteries getting run down, possibly during the night. However, they now cut the connections at the cells every night, and they had now no trouble at all with the batteries.

Mr BISHOP said that at Cadzow the wires got covered with coal dust, and every week a man ran along them with india-rubber, so that there was no time lost when a man wished to ring the bell.

On the motion of the PRESIDENT, a hearty vote of thanks was given to Mr Irvine for the trouble he had taken in connection with his paper, and the useful information he had given in it.

Since the meeting, the following communication has been received from

Mr IRVINE:—"The method referred to by Mr Young of winding resistance coils by doubling the wire (p. 100) is the one generally employed in winding such coils, but this being merely an instrumental detail, I did not consider it necessary to mention it, especially in the paper. It fulfils the conditions necessary for preventing self-induction—viz., one half of the wire is wound to the right and the other half to the left. The remarks made by

Messrs Bishop, Dixon, and Gilchrist as to the insulation of wires after having been erected for some time are explainable by the wires becoming oxidised. It is well-known that many metals when exposed to the air become coated with oxide, and many of these oxides have so great resistance as to have almost insulating properties. Mr Dixon stated that occasionally they had *to scrape the wires with a nail* before a signal could be transmitted, which, I think, clearly points to the existence of the oxide coating. With reference to Mr Bishop's remarks, in which he adduced a covering of coal dust on the wires as being the cause of insulation, I am not yet in a position to give an affirmative or a negative reply. In every hard and solid carbon we have a comparatively good conductor, *vide* the microphone and the electric lamp ; but whether coal is so or not, I have no information on the subject, but would imagine that it would also conduct electricity. But the fact of its existence in the form of a very fine powder may have—and in all probability has—the effect of producing insulation. At some future time I, however, intend trying a few experiments bearing on this subject, and shall be very happy to let the Institute have the result of such if desired. In my remarks as to the use of earth plates, I doubt very much if this subject was made clear. When the wires are arranged for all round signalling, and one bell is used, the use of an earth plate is not necessary, and at page 68 it is stated that the circuit can be completed by connecting the earth wire to the zinc pole, and this connection is also shown in fig. 4, p. 73, as a full line from the bell to the zinc pole, the earth connections being in broken lines. But where there are several bells introduced into the same circuit (as in fig. 7, p. 75), such an arrangement will not suit. With three bells joined in a continuous circuit and a battery composed of 32 cells (No. 2, Leclanche) I found that only one bell sounded, but with the arrangement shown in fig. 7, where each bell is connected to the earth, 12 cells are sufficient to sound all the bells. In the single wire system of signalling a return must exist, either by a second wire, pipes, rails, or earth plates. If any member desires a fuller explanation as to the use of earth plates, I shall be very happy to give him what information he desires, so far as I can do so. In

fig. 7, I notice that the wire from the duplicate battery is shown as connected to *one key only:* this is an error, and it ought to be connected to each of the three keys shown on the drawing. Chloride of ammonium is not formed in the cell, as stated by Mr Bishop, chloride of zinc, resulting from the decomposition of the chloride of ammonium, the zinc being dissolved.

DISCUSSION ON MESSRS BARROWMAN AND HASTIE'S REPORT ON MESSRS SMITH AND MOORE'S PATENT METHOD OF GETTING COAL.

The SECRETARY stated that, as instructed, he wrote inviting Messrs Smith & Moore to send men and material to try their system in the workings of this district, but he had not yet got a reply. Mr Birrell, Dunfermline, had, he understood, arranged to have a trial in his colliery on 14th ult., but he was disappointed to find that they had neither put in an appearance nor sent word.

Mr JAMES YOUNG wrote—In the discussion that followed the reading of this excellent report at last meeting, one important factor in the case did not, perhaps, receive the attention it deserved, viz., the comparative safety of getting coal by this method with that of blasting with gunpowder and other explosives. The discussion chiefly turned on the all important question of economy. But if coal can be got with greater safety to life and property by this method than by blasting with gunpowder, then this fact has to be taken into account when discussing the question, even on economical grounds. As the paper read on this subject before the Iron and Steel Institute, on May last, by Mr Moseley of London, may not have come under the observation of all the members, I have attempted to summarise the advantages claimed for the system by that writer in regard to safety. (1.) There is no danger of igniting explosive gases. (2) As our own Committee remarks, the lime is quiet in its action, unlike gunpowder, gun, cotton, or other explosives, its action is free from shock or concussion, and consequently (*a*) has no disturbing effects on the roof-

or on bodies of gas that might otherwise be harmless; (*b*) has no tendency to drive the flame through the gauze of the safety lamp; (*c*) not imparting any wave to the air in the working, the coal is brought down with the minimum of dust which it would seem is often so important an element in an explosion. It is perhaps also worthy of notice that this method, if it be found to be practicable, has something to recommend it from a sanitary point of view. The results of the chemical union of the lime and water being only a little steam (which will soon condense) and slaked lime, they are quite harmless, while the gaseous products of an explosion of gunpowder—nitrogen, carbonic acid, carbonic oxide, and sulphurous acid—are all hurtful to animal life; and the same may be said of the gaseous products of dynamite or other nitro-glycerine compounds. I venture to think it is of some importance to have the matter discussed from this point of view, because, as is well-known, the Government have been strongly urged in certain quarters to stop the use of explosives in certain mines, and, if we have in this method a substitute for explosives, even though it has many disadvantages, it is just possible that in the not very distant future the Government may see fit, in the interests of life and property, to entirely prohibit the use of explosives in fiery mines. At last meeting, Mr Sharp put a question to the Committee on the power of displacement of the lime. It might interest him, and possibly others besides, to know that at the meeting of the Iron and Steel Institute, to which I have already referred, Mr Moseley, in order it give an idea of the power exerted by the lime cartridge, exhibited two iron pipes which had been broken by the expansive force of the lime and steam, though one of them had previously been tested to a pressure of 953 lbs. per square inch. This is not so very much an evidence of the strength of the lime, because I have read of gunpowder bursting a pipe tested to 200 tons.

Mr DIXON thought that the system must be tested by experiment and experience, and if it was really what the patentees represented, it would very soon come prominently before them; if not, it would sink into oblivion.

Mr ANDERSON said the patentees themselves did not seem to have very much faith in the system when they were so very back-

ward in sending men to show how it was worked, and in replying to the letters sent to them. They might, he thought, have given their reasons for not sending down to let the people of this district know how to work the patent, especially after a deputation was sent from here to get all the information they could.

Mr DRINNAN was afraid Mr Anderson forgot that the patentees made an offer to come here on certain conditions. Of these conditions they had taken no notice. The conditions were that the expenses of the men were to be paid, and instead of offering to pay them they actually ignored the conditions, and said they would give every facility but the payment of expenses. He thought, after the expense they had been at, and considering how it would have added to the value of the report, that really they might have offered to pay the expenses. However, that was overruled at last meeting, and he believed the reason why the patentees took no notice of their letter was because the Institute took no notice of their conditions.

The PRESIDENT was inclined to think the Institute having sent gentlemen best qualified to form an opinion on the system, and the patentees having the benefit of their report, which cost them nothing, they were quite entitled to do a little. They would remember they had had their system thoroughly tested by gentlemen who knew what they were speaking about, and he had no doubt that, if these gentlemen had been able to report favourably, or very favourably, so would the instrument have made progress, or much progress. He thought the patentees had very little to complain of indeed. If it were right, as Mr Dixon said, it would go on with what they had done to help it; if not, it would go into oblivion. He did not think there was very much in what Mr Young said about the pressure being less. He believed it would be very much the same either way. He did not know whether the gentlemen might have remarked it or not, but he fancied it would depend very much on the nature of the coal. He thought that hydraulic pressure for bringing down coal had not been sufficiently tried. A very great power might be exercised by this means. Thus, supposing a 2-inch hole, bored 3 feet in, and a hollow plug put in tightly within a foot of the mouth of the hole, through which water at 1000 lbs. on the square inch was

put in, there would be a pressure of 24 inches by 2 inches by 1000 lbs., equal to 48,000 lbs. exerted on the coal.

Mr BARROWMAN said in preparing the report Mr Hastie and he were anxious not to make it long—to put the facts they had to state in as short compass as possible, and they therefore did not dwell upon things that were self-evident. One of these was that there would be less dust, and also there would be less breakage of the coal. Reference had been made to the expansive force of the lime. Where the lime was thoroughly stemmed, and the steam quite confined, no doubt the expansive force was very great, but as they had mentioned in their report it would not be very effective in an open jointed seam. They had had occasion to make some experiments, and they found while pressing in the water that it leaked through the joints of the seam. It was evident if they could press water through the cracks the force of the lime would be very much modified. They tried it in coal and also in limestone and found that result to follow in several cases. It was, therefore, from actual trials of their own that they were enabled to say that in their opinion it would not be very effective in an open-jointed seam. As to its being a substitute for gunpowder, he did not know that the patentees laid claim to that. They rather put it against the very laborious and slow process of wedging. Where such was required (and certainly in the seam in which they saw it at work it was required) the lime was doing good work. The seam, as the report states, was a hard seam, close jointed, and had a very bad parting from the roof. No mention had been made as to the novelty or otherwise of this method. Mr Moseley in his paper styled it a new method of mining coal. He did not know if it was a new method of mining, and he did not know that those gentlemen should get the credit of having introduced this method of mining. He found in the "Edinburgh Encyclopædia" of 1830, under the heading "Blasting," there was reference made to a Mr Headrick who "proposes to blast rocks by introducing the purest quicklime into the cylindrical hole instead of gunpowder. By suddenly slaking the lime he conceived that the expansive force would rend the stone to pieces.—See communications to the Board of Agriculture, Vol. II." The system of blasting large blocks of freestone by the

insertion of lime and water simultaneously into several holes in a line, and stemming them up, was in use thirty-seven years ago at Bishopbriggs Quarries, near Glasgow. The principle is known and applied in an ingenious way by the natives of some parts of Africa in the capture of alligators. The carcass of a goat or other small animal is filled with calcined sea or river shells and placed near the alligator's haunts. He helps himself to goat—feels thirsty—drinks—and shortly dies.

Mr ANDERSON said there was one point in the report they had not discussed, viz., that this system was much safer than the ordinary one. They had generally to come to the matter of economy after the safety was fixed. They were told that its cost was 2d per ton less than wedging, and that there was 2 per cent. more of round coal. Did they know how much per ton the patentees charged for the use of this apparatus, and also, what it cost to put it in operation? If they charged a royalty, and if the apparatus was very expensive to keep up, what would be the saving? There was 2d per ton less to the collier; what would be the saving to the proprietor if he adopted this system of getting the coal?

Mr BARROWMAN said the patentees were not then prepared to state on what terms they would allow this patent to be used. He thought they were in favour of imposing a royalty on the output of coal from the use of the lime.

Mr ANDERSON—It must be very small what they would ask, when the saving is so little.

Mr MACFARLANE did not know on what basis the patent was claimed, but he remembered thirty years ago blasting with lime. That was in rock on the other side of Pollokshields. The method was different, no doubt. The water got leave to go into the hole; there was no attempt at pumping, and it was a slow process, but it burst the rock. They put the lime in the same as powder, and it was pressed into the bottom of the hole.

The SECRETARY, referring to a statement in p. 84, said it appeared that twice as many holes were required for the lime as for the powder. He thought this must be against the system.

Mr SHARP was still anxious to know the power of displace-

ment of the lime. He asked Mr Barrowman if he could state how many gunpowder shots their ordinary Scotch miner would have in the face of 25 yards referred to?

Mr BARROWMAN could not tell from experience. The practice with gunpowder, he believed, would be a hole every 12 feet instead of every 6 feet, as in the case of the lime at Shipley.

Mr SHARP said so far as he had made enquiry—and he had a source of information on the subject—the system was almost equal to what a miner could do with a wedge. It would operate in their ordinary Virtuewell workings. In their Splint, Main, and Ell seams, where a shot would at all be required, it would, he believed, have no effect whatever.

The PRESIDENT—That is what we have got to test.

Mr BARROWMAN called attention to the drill which, he said, did its work well, and was of simple construction.

The PRESIDENT afterwards brought the discussion to an end by proposing a hearty vote of thanks to the deputation, which was cordially given.

The PRESIDENT announced that the summer meeting of the Institute was to be held at Stirling on Saturday the 19th prox., of which due notice would be given.

The meeting then terminated.

THE MINING INSTITUTE OF SCOTLAND.

SUMMER MEETING,

HELD IN THE

GOLDEN LION HOTEL, STIRLING,

ON

SATURDAY, the 19th day of AUGUST, 1882.

Ralph Moore, Esq., President, in the Chair.

The Annual Summer Meeting of the Institute was held in the Golden Lion Hotel, Stirling, on Saturday, the 19th day of August, 1882.

Before the Ordinary Monthly Meeting took place, nearly 60 members sat down to dinner—Ralph Moore, Esq., President, in the chair, and Messrs J. S. Dixon and James Smart, Vice-Presidents, acting as croupiers.

After dinner, the usual business was disposed of.

The following gentlemen were balloted for and admitted as Ordinary Members:—

JOHN GRAY, Coalmaster, Birkenshaw Colliery, Stonehouse.

WILLIAM CAMPBELL, Noshannon, Sobieski P.O., Clearfield County, P. A., America.

Another gentleman was nominated.

A NEW SYSTEM OF SIGNALS FOR COLLIERIES.

By Mr ALEXANDER M'CALLUM.

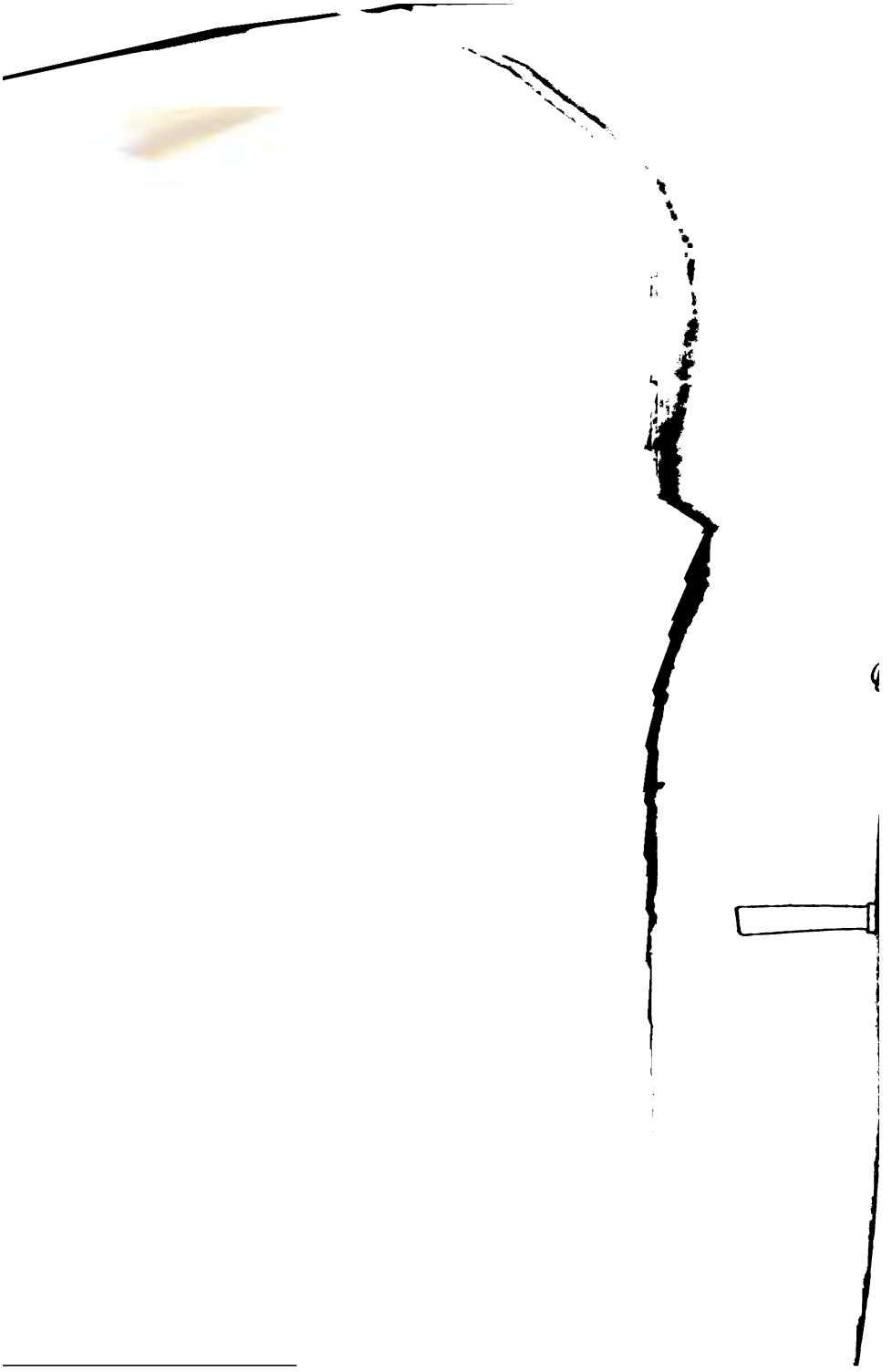
THE signalling apparatus about a colliery is one of the most important requirements that we as colliery managers have to attend to.

It is upon the efficiency of that apparatus that the safety of life and property to a very great extent depends; and, seeing this is the case, it is for us, who have the superintendence of coal and other mines, to see that we have at all times the most approved and best system in use, and at all times in proper working order.

Until very recently, we had almost no choice as to what mode to adopt, the hammer being the only one in use throughout the whole of the collieries in Scotland; but now, since the bells, springs, and electric battery have been introduced, we have the choice of a considerable number that we can apply to suit our varied requirements.

The hammer used to do, and is still doing, very good service, so long as we have no need to go any great depth in search of mineral. But, now that we are compelled, in almost every field throughout the country, to sink far down into the bowels of the earth before we can reach our coal beds, we find that this mode of signalling is almost useless, owing to the great weight we require to attach to bring back the wire. The deeper we go the more weight we require to put on, until we arrive at a point where we find it quite impossible for the bottomer to raise the hammer; and I believe this to be the case with all the other appliances yet in use, with the exception of the electric battery.

In our Niddrie Colliery, we have nearly reached a depth of three hundred fathoms, and, for a considerable time, I have found great difficulty, attended with very considerable expense, in keeping our signals in proper working order, because of the great length of wire, and its liability to stretch, through the excessive weight we require to attach at the surface to drop the hammer again, or ring the bell, as the case may be. This difficulty also refers to the return signals as well as the other. We sometimes find that, by the stretching of the wire, the man at the bottom



is uncertain whether the signal has reached the top or not; and, although it is the duty of the engineman to make sure that he gets the proper signal, yet we sometimes find that a good deal of time is lost through this misunderstanding.

As we are very shortly to go on sinking to a further distance of some seventy or eighty fathoms, I saw no way of continuing the present system of signalling, and, as it is said that "necessity is the mother of invention," I set my brain to work to find some other means by which I could accomplish my end, and the result is this simple apparatus now placed before you.

I have read that able, interesting, and elaborate paper, delivered lately before this Institute on electric signalling, but I must confess that I am a little sceptical as to the utility of the electric battery being applied to the working of the signals about a colliery.

I have used the electric battery for blasting in sinking operations. I have used it in the working of signals in mines, and I am at present in connection with it in transmitting messages. I have found it, under all these different appliances, apt to get out of order, and before it could be put right it tried the patience and skill of men who had had the best of training, and who had done nothing else for years but attend to the working and repairing of electric batteries.

I have objections to the battery because of its first cost, of the cost of its daily up-keep, and of its liability to get out of order. It is affected by the atmosphere, by water, and I am not sure but it is affected by the magnetic influence sometimes found in the metals below, and it sometimes strikes work because of its being too hard wrought. I believe also that it cannot be applied to the stopping of a train of hutches along a haulage road except by the working of it with two uncovered wires, to which a great many objections can be raised, such as the loss of electricity, the greater liability of its taking to earth, &c.

Now you all know what these stoppages mean about a colliery —loss of work to the miner, heavy losses to the employer, and great annoyance to those in charge of the works.

For these and other reasons I was forced to give up the idea of erecting an electric signal at our colliery.

This signalling apparatus that you have here placed before you

is one that will carry you to any distance that will ever be required in mining operations. It is cheaply got up, simple in its construction, all its parts can be seen at a glance, and it can be repaired in a few minutes if it ever happens to get out of repair. It can be made to stop a run of hutches along a haulage road almost in a moment, by placing levers along the side of the roadway every few yards. The man or boy in charge of the load has nothing to do but spring from his seat, draw the nearest lever, and the thing is done.

You see by the arrangements that, in working on an incline and bringing up a number of hutches at a time on one carriage, as we require to do at our Niddrie Colliery, the engineman can be under no mistake as to what platform is being loaded, as the pointer is standing at one, two, or three, as the case may be; so that until the pointer is shifted by the bottomer he cannot move again. There can be no dispute between the bottomer and engineman as to whether the signal has been given, for the pointer stands at the figure or other mark until it is shifted.

You may also see by the model that I propose to make it both an up and return signal, if I am within the limits of the law so to use it as I believe I am, if the mode adopted by the electric battery is within the law.

I certainly do not claim for this apparatus that momentary effect of delivery which the electric battery has the power to give; but I do claim for it that it is better adapted for a haulage road than that mode of signalling. No disturbance will interfere with the working of it, except the breaking of the wire which is to be met with in all other working signals as well.

I do not think there is any necessity for me to lengthen out this paper in giving explanations as to how this signal is wrought, as you have here the model before you, which is so simple that any one seeing it can at once understand it, as it explains itself.

Those interested in such things throughout the country, who may think it worth their while to look over this paper, will understand it clearly by looking over the accompanying drawing (Plate 1.) They will see that it is an endless wire working over

two chain wheels, the wires being attached to the chains. The wheels are hung on spindles to which handles are attached, which work all the parts of the signal.

A dial-plate, with pointer, is also affixed to the same spindle, the pointer indicating the position of the loading platforms, and also working the bell, or bells, when required to be used, as in the case of men riding or at any other time to call the attention of the engineman.

I have said bell or bells as I intend attaching another for shaft work, with a different tone of sound; and by putting up a few levers along the wall of our incline, so adjusted as to strike this bell, we will be able to work our repairs by the same wires, or in going up and down an incline if a stop is wanted it can be effected by these levers.

Although it was my main object to find a signal to suit our requirements at Niddrie Colliery—which I believe this will accomplish—it can be applied to any colliery as well, and to any haulage road above or below ground.

It cannot be used for more than one bottom, but we can put up one for each bottom, as we will sometimes have two or three in one incline.

We have had many more at times, but I find it better to run down the material to a main bottom by means of self-acting drops.

A separate signal is required in all bottoms at every colliery, so that there is nothing extra added in this case.

I do not think I can add more. I know there are gentlemen present who are both able and willing to criticise all defects that it may have, and I shall wait patiently to hear what these defects are, so that I may be able to improve my system.

The PRESIDENT said this was an application of an endless rope signal, a very important one; and he thought they would best do it justice by deferring any criticism on it until the paper was printed. However, if any gentleman had any remarks to make, he would be glad to hear them.

Mr ALEXANDER asked if they would not require first to call the engineman's attention by means of a bell?

Mr M'CALLUM explained that this object was accomplished by means of silent signals, raising and dropping a weight, and it was entirely a matter of sight.

Mr ALEXANDER—Can you rely on the engineman observing them promptly?

Mr M'CALLUM said, his impression was that it was more secure than sound.

The PRESIDENT said, there might be six or eight or sometimes a dozen openings or bottoms in an incline. Each of these had a signal for itself. There was a lever across the opening into the incline, on the end of which there was a crank, to which the wire was attached. That raised the visible signal in the engine-house, so that when the lever was up the signal was also up, and when it dropped it acted as a fence to the incline. The use of this particular signal was that it showed to the engineman when a man was at an opening with a tub to put on the cage or carriage. Until he stopped the cage he could pass up and down as often as he liked, but whenever he did stop the cage at that man's place he must not remove it until the signal is down and the entrance barred again. In that way it was far better not to have sound signals but rather those visible signals, because there might be a dozen calling at one time, and he (the engineman) knew distinctly so long as he did not stop he could move as much as he liked, but whenever he stopped he could not move without a signal.

Mr ALEXANDER said he had had to do with a special working of this kind, but that was not the arrangement followed. They first directed the engineman's attention to the signal board, and then the pointer indicated what was wanted?

The PRESIDENT—As Mr M'Callum had remarked, the objection came in on account of the long distance he has got to work down, making the balancing of weights a rather difficult work.

Mr ALEXANDER—Then this is a specialty.

The PRESIDENT said it was a mode of signalling that was about perfect. It had been working for years, and he supposed they found it to work very well.

Mr M'CALLUM said that it worked splendidly. They avoided putting all the strain on the wire.

Mr DRINNAN said it struck him that there was a good deal in what Mr Alexander was saying. There was much necessity for the engineman's attention being called by a signal, and he thought it was necessary to call Mr M'Callum's attention to the matter, with the view of seeing whether he could not answer the objection that had been taken. Probably they were all aware that where there were a number of bottoms there was a larger output from one bottom than from another. Now, it might be, where there was a very small output from a particular bottom, the engineman might be likely to get into the idea that he would not require to stop there for a number of hours, and he might omit to notice the signal when no sound was given. As it struck him as quite a possible thing to give a signal and call the attention of the engineman, he thought it was a safeguard lest he should attempt to run past it where the lever was down, for, just because he did not require to stop so frequently, he might not stop when called. Perhaps Mr M'Callum would suggest something in this direction that would enable them to come to a decision with much fuller knowledge before them than at present.

Mr ALEXANDER—It is what they do when forwarding a telegraph message. They ring the bell. It should be the same here.

The PRESIDENT, referring to what had fallen from Mr Drinnan, said no matter how often the engineman might go past,—he might go past all day if he liked,—he never possibly could do any harm to a man working with the signal up. It was a little different from the case Mr Drinnan put, because every room here was a bottom. The engineman had before him the numbers,—1, 2, 3, 4, 5, 6, 9, 10, as it might be,—and he looked at them. If one, two, three, and four were down, he stopped at any of them he liked.

Mr DRINNAN was afraid he must have spoken under a wrong impression as to the lever that had been referred to. He had the impression that it was something that projected into the shaft or incline, and his remark had been founded accordingly.

The PRESIDENT—It is simply a bar that blocks the level opening.

Mr ALEXANDER—Each man is his own bottomer?

The PRESIDENT—Each man is his own bottomer.

Mr M'CALLUM—But it does not apply unless you have a certain number of men.

After a few more remarks, the discussion was adjourned to a further meeting.

EXPLOSIONS OF FIRE-DAMP.

BY MR J. T. ROBSON.

IT will not be denied that the recurrence of explosions of fire-damp in mines is a subject which ought to be brought before the Institute from time to time, so that members may have opportunities for discussing it, and for communicating their views and experience thereon, as well as for offering suggestions, which, in their opinion, may tend to lessen the number of explosions, and to diminish the effect of them when they unfortunately do occur. It is for this purpose that the writer has undertaken to introduce the matter.

To most of the members fire-damp is well-known, but it may not be out of place to note shortly some of its leading features.

Fire-damp is not a purely elementary gas, but it is a mixture of carburetted hydrogen, nitrogen, and carbonic acid, with sometimes the addition of oxygen and other gases. Analyses of fire-damp show these components in various degrees, but, as a rule, carburetted hydrogen is the chief one. The inflammability of fire-damp, when mixed with air, varies in proportion to the proportions of each. It also varies in proportion to the amount of carbonic acid which the mixture contains, and it is believed that 14 per cent. of carbonic acid will render non-explosive the otherwise most explosive mixture of fire-damp and air. It thus happens that in partially ventilated (or unventilated) places there may be fire-damp present although it does not show itself in a safety lamp; in most of cases, however, it does show itself by exhibiting a brownish cap on the flame, or, when the proportion of carbonic acid is large, by putting out the flame. It is then

said to be "damped." When fresh air is brought to bear on such a mixture there is a critical point reached, and instead of the mixture remaining non-explosive it will become explosive. In the purer state fire-damp shows a pale blue cap on the flame of a safety lamp, but in return airways the cap, if seen at all, is generally more of a brown than a blue colour. Apart from colour-blindness, it is possible that one person may fail to see fire-damp where another may see it, as it requires a certain amount of practice and good eyesight to enable it to be detected when present only in a small proportion. Probably 2 per cent. is the smallest proportion which can be detected by means of the safety lamp.

The probability is that fire-damp exists, or has existed, in all seams of coal, shale and other carbonaceous strata, yet it is not *found* in all mines. It is not always met with in larger quantities as the depth becomes greater. Some seams, and even some districts of the same seam are almost exempt from its presence, while others in the same locality invariably give it off. In the workings of fresh districts, and where the seams lie at a considerable depth, there is every probability that fire-damp will be met with, coming either from the coal or other mineral, or from the strata above or below it.

Where a seam gives off gas, the normal discharge may be affected by an alteration in the compactness of the mineral, and the nature, extent, and direction of the cleavages. Thus, a place at right angles to the regular and continuous cleavages if driven much in advance will probably give off more gas than one similarly situated, but in the direction of the cleavages, because the former would drain gas from both sides as well as from the front as each cleavage was reached, while the latter would drain it mostly from the front, the parallel cleavages preventing to some extent its flow from the sides. When there are cleavages in both directions the discharge of gas does not vary much between "ends" and "planes." The normal discharge is sometimes affected by the dip and rise, but although gas is generally seen more in places going to the rise than those going to the dip, the latter may be producing quite as much gas; indeed, where the field is clear of faults, the coal all solid to the dip, but

worked to some extent on the rise, there is even a likelihood of more gas being produced in places going to the dip than in those to the rise.

Fire-damp may be given off gradually, and, especially in dry seams, imperceptibly, or it may be accompanied by a slightly singing noise. It sometimes rushes from fissures or cavities in large quantities in a few minutes. These "outbursts" of gas, which are always at a high pressure, have in many instances burst out the coal from the solid face for distances of 6 or 8 feet, and in others have riven the pavement for several yards in length, and broken down large portions of roof. It has been known for gas to force itself through columns of water from five to ten fathoms in depth.

In general cases there is more fire-damp met with in the vicinity of hitches and foul coal than when these are absent, and there can be no doubt that faults often afford means for gas ascending from an under or descending from an upper seam. The occurrence of a fault often alters the amount of gas given off —a place may have produced little or no gas, but on crossing a hitch a larger quantity may be given off and the discharge continue, or the reverse of these circumstances may take place. In the vicinity of large faults there is a probability of meeting increased quantities when approaching from the dip, or on reaching and crossing them from the rise.

It has been proved by boring that fire-damp has existed at a high pressure within a very short distance of the coal face, although it issued at a pressure little above that of the atmosphere at the face. In the most recent experiments, which are reported in the Transactions of the North of England Institute, a pressure of fully thirty atmospheres was registered in one instance. Although there is not the same probability of such exceedingly high pressures obtaining within a few yards of any face in fields fairly opened up, and especially where the collieries are comparatively adjacent to each other, there may still be such pressures that under favourable conditions a large inrush of gas might take place. The matter is certainly one which requires more investigation and study.

Meteorological influences have, to a certain extent, an effect on

the condition of mines; but it is doubtful whether they will affect a mine, which is thoroughly ventilated, to an extent sufficient to make it dangerous. It has been noticed in some mines that the coal on the sides and in the neighbourhood of main intakes sometimes cracks and splinters off during very hot weather—probably owing to the expansion of the coal. In like manner, the gases contained in the coal are expanded, and if such increase of temperature be accompanied by a considerable diminution of pressure, there is certain to be a more than ordinary discharge of gas at a time when the air does not possess its maximum strength to cope with it. Gas which may happen to be in a goaf beyond the reach of the ventilation, will, under the conditions stated, expand, and unless carried away by the current which sweeps the goaf edge, may reach the working places.

CAUSES OF EXPLOSIONS OF FIRE-DAMP.

In the broadest sense, explosions of fire-damp are caused by a body of inflammable gas (a mixture of fire-damp and air, containing from 7 to 25 % of the former) coming in contact with a flame or incandescent substance. Although air is necessary to the formation of an inflammable mixture, it is the best known means of destroying that inflammability; moreover, pure air is as indispensable in a mine as on the surface. It remains, then, to be considered how fire-damp can best be rendered harmless. For the present purpose it will be better to enumerate the different causes or conditions which lead to the accumulation of fire-damp, and to state the steps or precautions taken, or that might be taken, to remove these causes or conditions where possible, or to obviate their effects where that cannot be done.

Accumulations of fire-damp may be the result of any of the following causes :—

1. Improper Distribution of Air Currents.—The chief points to aim at in the proper distribution of air are (1) to have a suitable number of air-courses constantly maintained of a sectional area large enough for the requirements of the workings and the persons employed. Care should be taken that there are no unnecessary obstructions to its free passage, the due proportion allotted to each division being regulated by the distance travelled, as far as this

can be done, and artificial regulators only used where natural means are unavailable. The respective currents should be conducted by permanent ranges of stoppings as directly as possible to the various divisions or sections, and thence by temporary stoppings, doors, screens, and bratticing around the extremities of the workings. (2) The velocity of the currents being of importance, both as regards safety and economy, this matter should be carefully studied in the arrangement of air-courses, their number and sizes. Neglect of this may entail a serious loss in the aggregate quantity of air. Except for short distances near the shafts, where the number of openings is necessarily limited, the velocity of the air can be kept within reasonable limits by having a separate intake and return for say every 15,000 to 20,000 cubic feet per minute, which, in an area of 50 to 66 square feet, gives a velocity of 300 feet per minute. As far as practicable the requisite quantity of air should be obtained by additional airways rather than by high velocities in a single one. In extreme cases, and especially in highly inclined seams producing much fire-damp, it may sometimes be absolutely necessary to force such a quantity of air through a single passage that the velocity will exceed 300 feet per minute, but the danger will be greater than it would be if the gas could be dispelled by a lower velocity. (3) As every door on a main road is a source of weakness, they should be avoided as far as possible, and where they cannot be dispensed with there should be double doors. Principal returns are better kept clear of traffic, and passages communicating with them are better provided with man-hole doors than large ones. (4) If a current should be so charged with gas as to show it in a safety lamp the quantity of air should be increased, if practicable, or the length of faces ventilated by it reduced; if, however, neither of these alterations can be carried out, some of the faces should be stopped so that the current may be brought within safe limits as regards the proportion of gas contained in it. A highly-charged current should not be allowed to spread into or through a waste. (5) The ventilation of wastes should be ensured by systematically taking air through them, and it is better to have the returns situated at the rise of the waste.

2. *Improper or Defective Systems of Working.*—There can be no

doubt that some methods of working are much more conducive to accumulations of gas in the workings than others. For example:—Any system by which numerous small goaves are formed, too large for thorough ventilation and too small for allowing the strata to subside sufficiently to close them, is defective. Again, the formation of large areas of pillars, where the roof is likely to fall in the rooms, is not desirable. Especially is this so where there are unworked seams in close proximity from which gas may come; and even where an upper or lower seam, within 10 or 12 fathoms, is being worked within the same area the action of such working may cause the strata to break and gas to descend or ascend into the waste. Where a seam of coal has a bad roof and is worked on the stoop-and-room method, it will generally be found that the better and safer plan is to follow the solid workings with the stooping. In such a case the working places in the solid should be kept at a proper distance, say three or four pillars in advance of the stooping. The air should be taken first to the solid and return by the stooping, sweeping the edge of the goaf, into the main return. If the district is a large one, the stooping should have a separate current supplied from the main intake, and in any case this will be a safer plan where the solid workings produce much fire-damp.

Where the roof is good and the workings not likely to be affected by other seams, either solid or in course of working, there is not the same necessity for following the faces by the removal of the pillars, and a district may be entirely finished in the first working before the second operation is begun. In this case, it will be better to begin at the extreme end of the district and work backwards, and the ventilation should be so arranged that the current will reach the highest point of the goaf edge and return in an air-way clear of traffic, if possible, towards the upcast.

The formation of a goaf may become a matter of serious difficulty if it is begun in a small area and then stopped. The question ought, therefore, to have mature consideration before a beginning is made. In general cases it would be unwise to commence with a breadth of less than 150 to 200 yards, and probably a breadth of 300 yards is not too much where the roof is strong, and, therefore, with difficulty broken off so thoroughly

as to close the goaf. To facilitate the falling of the roof over the entire area of a goaf, a straight line should be selected at which to commence, and the two outer sides should also be kept in straight lines. The side which is being worked at should be maintained of a regular form throughout, all advancing at once at the most suitable angle with the drifts for safe and economical working. With a view to reduce the length of the outside edges of goaves, which are the parts requiring to be ventilated, it is better to make them continuous than to leave off and then begin at a point further in or out, as the case may be. Thus, the area of one goaf 300 yards by 900 yards is the same as the united areas of three goaves each 300 yards square; but the edge of the former is only two-thirds that of the three goaves put together. It is true that in working back from a boundary or fault, unless an air-way is left at the other side, this side cannot be ventilated; but the fact remains the same that with fewer separate goaves there will always be a less length of edge affecting the safety of the workings, and requiring constant attention, than with a larger number of goaves, although the aggregate area may be the same in each case.

As a general rule, gas is more likely to be forced out from an inaccessible part of a goaf into working places or roads soon after pillar workings commence than subsequently; but a great deal depends on the nature of the roof for the first 20 or 30 feet, and, consequently, on the extent of open space near the edge where gas may lodge.

3. *Inattention to details and failing to take ordinary precautions.* —It is not uncommon, especially in long-wall, to find that, owing to hitches, inferiority or extra hardness of the seam, or it may be the irregularity of the miners in working, some portion of the faces is allowed to fall behind the general line and cause a difficulty in the ventilation which may lead to an accumulation of gas. It may not be possible at all times to avoid this, but it is a matter which requires continual attention, so that means may be devised for securing the greatest uniformity in working, and, consequently, the largest amount of safety. That accumulations of gas have been caused by failing to take the most ordinary precautions is beyond doubt; but these failures are, doubtless, more the result of errors of judgment than gross negligence. Amongst

the common causes are (1) failing to lead the current forward to the faces of working places; (2) leaving places standing in the solid without brattice; (3) leaving cavities in the roof of roads open, and without a current of air directed through them; (4) failing to have a current sweeping the faces of the brushing, open cundies, or other places where gas is most likely to lodge; (5) altering ventilating arrangements without a careful study of the circumstances before beginning, and great watchfulness during the operation.

4. *Neglect of Instructions and want of Care on the part of Workmen.*—The most common cases where accumulations of gas arise through the action or by the neglect of workmen are (1) damaging, interfering with, or removing screens, brattice, or doors; (2) leaving doors open; (3) allowing falls to occur in their working places by irregular work or insufficient propping and securing; (4) throwing into or leaving rubbish in the entrance to aircourses. These acts or omissions ought to be dealt with in a proper manner by those in authority.

5. *Falls in Airways Obstructing Ventilation.*—As far as practicable, airways might be brushed up to a good bed so as to avoid having to support the roof by timber which requires constant renewal. In cases where this cannot be done, and where there is a liability to falls, it would be well to have all principal returns laid with rails, so that when falls occur they could be cleared away at once. The examination of return airways should be very frequent.

6. *Partial or Total Stoppage of Appliances for Producing Ventilation.*—Since the more general introduction of mechanical means for producing ventilation, accumulations of gas from this cause have been of less frequent occurrence. It seems quite necessary that there should be a proper person, both day and night, to attend to the machinery, or furnace as the case may be, so that the ventilation may be constantly maintained. The attendant should have definite instructions for the work, and also how to act in case of accident or stoppage. Repairs should be done while no person is in the workings, and always so as to interfere with the ventilation as little as possible.

7. *Blowers, or sudden Outbursts rendering the Mine, or part of it,*

Explosive, where the Ventilation during ordinary circumstances is efficient.—As previously referred to, fire-damp often exists at a very high pressure, even within a few yards of a face, and it is not to be wondered at that, under special conditions, it is capable of breaking through the intervening material and rushing into the workings in an abnormal quantity and at a high pressure. Such conditions as foulness, softness of, or fissures in the mineral or strata seem favourable to sudden outbursts. Where there are strong feeders from coal the chances of a sudden inrush of gas may possibly be greatly diminished by boring in advance, because the hole would drain the gas and the point of high pressure would thus be placed further from the face. Boring holes upwards or downwards may also be beneficial in relieving the pressure in upper or lower strata. Generally, it seems to be a necessary precaution to drive leading places slowly, where these give off gas freely, in order to give more time for the gas to drain off to a further distance in advance of the faces.

8. *Insufficient Ventilation.*—Probably a fair definition of this is the following:—The ventilation of a mine is deficient if, under normal conditions, and after taking ordinary and proper means to carry forward the current, fire-damp should be found in any accessible place in sufficient quantity to cause a small explosion. It may be urged that the conditions of a mine are continually changing, and that these changes, though small in extent, may necessitate different modes of treatment, which require time to carry out. This is quite true, and it is this liability to change which makes it incumbent on those in charge to be ever on the alert, so that no time is lost in carrying out from time to time the proper means for ensuring adequate ventilation.

In every mine some, and in extensive mines a considerable amount of engineering knowledge—both of a practical and theoretical nature, is required to design and carry out the appliances for producing ventilation. The various matters requisite for the distribution of the currents must be continually studied so as to keep pace with the development of the colliery. Next in importance is the careful and efficient carrying out of details, chiefly entrusted to oversmen and firemen, to obtain the full benefit of the various currents into which the air is divided.

With regard to the second factor in an explosion—the presence of a flame or incandescent substance—the questions to consider are:—(1) The lighting of the workings; and (2) the mode of getting the coal, whether by the use of explosives in coal or stone work, or by dispensing with explosives.

In all mines known to produce gas, even when sufficiently ventilated and worked on approved principles, there is a possibility of it appearing in dangerous quantities, and how far it is safe or proper to use naked lights where this may happen is a matter for serious consideration. It is imperative to use only safety lamps "in every working approaching any place where there is likely to be an accumulation of explosive gas," and there are many other cases where experience has proved the wisdom of the same precaution being taken. For example, in the pillar workings of seams known to produce fire-damp occasionally; in proximity to falls of roof or places inaccessible to the ventilation; generally where, owing to some obstruction, damage, or other cause, the ventilation is not in its usual condition; while making examinations or repairs in return aircourses or wastes; where outbursts of gas are probable. In at least all these cases the use of safety lamps only seems a reasonable and proper precaution to take. The practice sometimes seen of allowing a workman to have a naked light as well as a safety lamp is a very improper one.

With reference to the use of explosives, and their effect, so far as producing a flame is concerned, in mines where fire-damp may exist, there cannot be two opinions as to the necessity for proper restrictions being placed upon their use; and also for the greatest amount of care being taken where they are allowed to be used. Under certain conditions of a mine, shots can only be fired if it is found safe to do so; and there may be a difference of opinion as to when it is safe to fire a shot, and when it is unsafe. This highly important point is put upon a competent person, usually the fireman of the district, to decide from time to time. There can be no doubt that, when a careful fireman finds gas in or contiguous to a place, he will decide that it is unsafe to fire a shot in such place; yet there may be many cases where, although gas may not have been actually found, it would be unsafe to fire a

shot. The matter certainly demands the best attention of all those who have to appoint the men who give effect to this rule, so that the latter may have a full knowledge of its significance and influence on the safety of the persons employed in the mine.

Where experience has proved the necessity for the exclusion of naked lights, blasting should also be dispensed with wherever it is practicable to do so. Indeed, except in strong stone work, which, unfortunately, cannot profitably be done by any other known means, explosives are rarely resorted to where safety lamps are in use. In some cases where this is being done, it is the practice to fire shots only while no person but the shot-firers are in the pit—that is, between the end of the colliers' shift and the beginning of the brushers' and builders' shift—the holes all being bored during the previous brushers' shift. This practice, which seems to work well, is well worthy the serious consideration of those who may happen to be similarly situated.

The extreme importance of good discipline in the objects under notice must not be overlooked. Whether in the working, ventilating, or lighting of a colliery, or in the use of explosives, where this is permitted, the strictest observance of rules and regulations is absolutely required, and it may not be too much to say that, unless these are faithfully observed by the persons in charge, and rigidly enforced by them on those under them, the very best system of working and ventilation may be ineffectual in the direction of reducing the chances of an explosion.

Although not included in the subject of these remarks, it may not be out of place to mention the question of coal dust. While it is a fact that all the large explosions, in recent years at least, have occurred in mines generally dry, and where there were large quantities of dust, which apparently tends to the conclusion that dust at least increases the force and extends the bounds of an explosion, it must be kept in mind that damp or wet mines, which are invariably shallow, are seldom fiery to any great extent. Still, although it has not been proved that dust has been the sole explosive in any one instance, there does not seem room for doubt that it has been an active agent in some of the large explosions in the kingdom. The latest experiments made in England appear

to show that the danger from this source may be greatly diminished, and apparently without injury to the roads, by an application, at intervals, of common salt. Where there is no tendency for the pavement to heave, watering the roads is probably the cheapest and best means of doing so.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 14th SEPTEMBER, 1882.

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Thirty-three members were present at the meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

THOMAS LITHGOW, Langbyres Colliery, Omoa,

was balloted for and admitted as an Ordinary Member.

Other two gentlemen were then nominated for election, and will be balloted for at first meeting.

SOME FEATURES OF GERMAN MINING,

Compiled from the Report of MM. A. Pernolet and L. Aguillon, to the French Commission on Firedamp,

BY MR JAMES H. RONALDSON.

A FRENCH Commission on firedamp appointed in 1880 two of their members—MM. Pernolet and Aguillon—to visit England, Belgium, and Germany, and make a report on the fiery mines of these countries. The first part of their report on Germany is occupied with the mines of Saxony, the second with those of Prussia and of Lorraine. The following paper is compiled from the latter part, which seemed to me to be of a more interesting character to us than the former. In the translation, I have maintained the general order of the original, and no matter external to the report has been introduced.

REGULATIONS FOR FIERY MINES.

PRUSSIA.

The administration to which mines in Prussia are subject in pursuance of the Prussian law of 24th June, 1865, having been made widely known by M. du Souich in his report on the regulations for the working of fiery mines, the Commission has little to add and can pass over it, as well as the general rules issued by each of the five Mining Boards (Oberbergämter).

There is only one observation to be made regarding the special rules, the chief examples of which have also been given by M. du Souich.

Within the jurisdiction of the Oberbergamt of Bonn every mine is required to have a special set of rules which is drawn up by the coalmaster and submitted to the approbation of the Oberbergamt; whereas, within the jurisdiction of Dortmund it is the administration which resolves upon and imposes special rules on a mine, the coalmaster being duly heard when it is thought useful to do so. This happens notably after an accident. There are actually some thirty sets of these special rules which have been made for the Ruhr basin, where the number of mines worked is above 250.

The administration consists of, in the first place, the Revierbeamt, the engineer in charge of a district called Revier; and in the second, the Oberbergamt, consisting of a board of six or seven members. The Revierbeamt is the actual chief of the service in his district, and gives actual decisions, subject to appeal, which the coalmasters can always bring before the Oberbergamt, decisions necessarily in conformity with the general or special instructions which may emanate from the Oberbergamt, and which it may be said in passing, seemed very rare in the Dortmund district, at least so far as ventilation and firedamp are concerned.

To those who know the extent of the powers of the mining authorities in Prussia, and to what degree the coalmasters are, even in the smallest details, under the eye and the hand of the administration it is a little astonishing to see the wide tolerance allowed by the administration in these matters, especially considering the accepted notions in Belgium, and in France generally. Examples of this will be shown further on.

The extent of the districts of inspection is very similar to that of the districts entrusted in Belgium to one engineer. Thus, the districts of E. and W. Dortmund, mentioned as the most fiery, are as follows :—

	Dortmund.	
	East.	West.
Number of Collieries, ...	20	15
„ „ Pits, ...	20	39
„ „ Workmen, ...	6,300	6,500
„ „ Tons, a year, ...	1,125,000	1,350,000

The collieries of a district are moreover grouped together within a small radius and near the residence of the inspector (Revierbeamt). The administration (Oberbergamt) has prescribed that the fiery mines in a district be visited by the inspector at least four times a year.

Each year, every coalmaster must send to the inspector, the plan of the workings he counts on executing during the following year, and to which plan the inspector may object within 15 days. If no observation is made by the administration within this time the plan and all the works leading to its execution are considered as authorised. Those prospective plans (Betriebsplan) which the Commission saw, are, however, only simple sketches of the future workings as a whole, little detailed, but always indicating the general course of the air-current.

The laxity which the administration seems to show on the question of firedamp and ventilation, arises without doubt from the feebly fiery nature of the mines of Westphalia up to the present time.

ALSACE LORRAINE.

The legislation of the mines of Alsace-Lorraine is based on a law of 16th December, 1873, which is, as regards the rules and supervision of the mines, only a reproduction of the Prussian law of 1865.

The Chief-President of Alsace-Lorraine, whose authority corresponds to the Oberbergämter of Prussia, issued on September, 6, 1879, general rules of direction of a nature similar to those of Prussia. They consist of 120 articles bearing on all that concerns the working. A single paragraph is devoted to ventilation and lighting, of which the most salient features are as follows :—

The use of the safety lamp, without mention, however, of the

type, is compulsory; as also the daily visits before the entrance of the workmen; the use of fire-lamps or all other open fires for ventilation are prohibited; furnaces cannot be established without an authorisation from the administration.

Special rules, within the bearing of the law, may, in addition, be imposed on a mine by the inspector (Bergmeister) after having heard those interested. In the rules thus laid on the mines of Sarre and Moselle for the conduct of the ventilation and lighting no striking peculiarity is noticeable save that all work to the rise (en remonte) requires a previous authorisation.

FIREDAMP.

Firedamp, though of comparatively slight abundance in Prussia, is found in the workings of various basins, creating, however, no real difficulties except in the Ruhr and in the Sarre, where, from time to time, accidents from firedamp are heard of. For these reasons the commission has deemed it sufficient to extend its observations to the Ruhr and the Sarre basins alone.

The coal in these different districts is found, as regards the hewing, in conditions analogous—if we except the thickness of the seams which is generally greater—to those met with in Belgium and in the north of France. That is to say, the seams are usually divided into beds of various thicknesses by partings of shale, more or less tender; but never in these beds does the coal, however well defined the cleavage may be, appear as a whole in planes of easy separation as in the English seams. There, as elsewhere, the fiery seams are usually more tender than the others. The roof and floor of the seams, without having the wonderful solidity of English measures, are generally more solid than those of Belgium and France.

Generally, as far as the commission could judge from all the information obtainable during its visit to Germany, it may be said that firedamp is nowhere very abundant. Certain seams, in the Ruhr as well as in the Sarre, have absolutely no firedamp and are worked with the naked light. These seams constitute distinct mines independent of those worked with safety lamps.

Firedamp does not appear in quantity worthy of note, except in those parts covered by "morts terrains" (north-east of the basin of the Ruhr and Lorraine), and in particular where the

ground so covered is also disturbed and faulty, as in the Albert Schacht part of the Gerhard-Prinz-Wilhelm Colliery of the Royal Collieries of Sarrebrück. In no part of England, nor even in Belgium, did the Commission see more fire-damp than at the pit L'Hôpital, situated in a highly disturbed and deeply covered part of the Sarrebrück basin which runs into Lorraine.

In the Royal Mines of Sarrebrück, where there is little firedamp except in certain troubled points, the following fact is curious enough to note:—In the Royal Colliery at Dudweiler Jägersfreude, a new pit, called Camphausen, has just been opened to the dip of the old pits. The first seams have been restruck at Camphausen at a depth of 542 yards, whereas the workings in the old mines to the rise have gone no further than 438 yards below the surface. In addition, the first roads made at Camphausen are still, as a whole, so many *culs de sac*, whereas, to the rise, all the workings are open to the out-crop. In spite of such differences of position, firedamp appears no more abundantly at Camphausen than in the old workings.

In these regions the disengagement of firedamp is normally of a gradual character at the moment the coal is attacked, and is, moreover, with the exception of Styring and L'Hôpital, sluggish enough to be diluted by a generally feeble current of air.

Blowers of firedamp are much more rare than in England, and have never been so important nor so continued. However, at Styring, in Lorraine, the galleries across measures often encounter in the neighbourhood of the seams blowers so strong that work must sometimes be suspended for one or two years. The sudden outbursts of England and Belgium are still absolutely unknown in Germany.

Of the countries visited by the Commission, Prussia is the one which can claim the relatively shortest death roll from explosions of firedamp. As the official statistics do not give the number of accidents, it is impossible to make a complete statistical comparison with Saxony, England, and Belgium; but the calculation for the period beginning in 1871, of the number of workmen killed per 1,000,000 tons extracted, shows that in Prussia, one workman was killed on an average, while for same period the number was in Saxony, 2·9, in England, 1·9, and in Belgium, 1·5.

I.—TABLE FOR YEAR 1879.

MINERAL DISTRICTS (Oberbergamtes bezirk).	Collieries in Activity.	Total Annual Production in Tons.	Workmen employed at bottom and at bank.	WORKMEN KILLED.							
				General Total.		By Firedamp.				By Bad Air.	
				Total.	Proportion per 1000 Workmen employed.	By Actual Explosion.	By Asphyxia.	Total.	Proportion per 1000 Workmen employed.	Total.	Proportion per 1000 Workmen employed.
Breslau, ...	148	11,196,987	41,060	129	3·141	2	1	3	0·073	1	0·024
Halle, ...	3	33,773	312	1	3·205	...	...	...	...	...	...
Dortmund, ...	202	20,380,421	77,096	245	3·178	41	2	43	0·558	4	0·052
Bonn, ...	30	5,769,322	27,766	67	2·413	6	...	6	0·216	2	0·072
Clausthal, ...	13	294,145	3,318	2	0·603	..	...	...	...	...	...
Totals, ...	396	37,674,648	149,552	444	2·968	49	3	52	0·347	7	0·049

In making an analysis of the causes of the accident from firedamp in the district of Dortmund, where alone they reach any importance, it was found that for 43 victims in 1879—

Four were killed in a single explosion which occurred in a gallery aired by pipes, the lengthening of which in time had been neglected;

Ten in seven accidents caused by blasting with powder, by the opening of safety lamps, or by travelling in abandoned districts;

Two burnt by firedamp, which they lighted through using their lamps without precautions;

Finally, twelve were killed in a series of local explosions which occurred in points where till then firedamp had never been seen, and where no precautions had been taken against it.

The cause of the gravest accident of 1879 is the cause of a large number of accidents in Germany, where airing by pipes is used without reserve.

The first grave accident which befel Westphalia was that of 15th January, 1868, at the mine Neu Iserlohn, near Langendreer, which cost the lives of 81 workmen. In the same mine an accident occurred on the 12th December, 1870, which caused 35 deaths, and another on the 8th January, 1880, by which 23 workmen perished.

The accident of 15th January, 1868, took place when the workmen entered the mine, towards five in the morning. During the habitual suspension of work for two hours between the night and day shifts, firedamp had accumulated in a seam where the ventilation had been stopped by the leaving open of two doors. The mine had a single shaft which had only a division for the upcast in its upper part between the surface and the level of the air return. Of the 81 victims 11 only appeared to have perished in consequence of their burns; 28 others had been burned, but appeared rather to have been suffocated; all the others simply perished from suffocation.

CONSTITUTION AND WORKING.

By the Prussian law of 24th June, 1865, every application for a concession (Muthung), after the minerals to be conceded are

proved, gives the right, for the profit of those who make the exploring work, to a field defined in plan by straight lines, and in depth by vertical planes passing by these lines. The uniform extent of this field is 612 acres, but several may be united to form one colliery with the sanction of the Oberbergamt, and in fact in the Ruhr district these consolidated fields (consolidirten felden) vary from 612 to 6,742 acres.

As a consequence of the perpetuity of the mining property granted to the coalmaster by the Prussian law, joined to the great number and closeness to one another of the coal seams in the Ruhr and Sarre basins, the collieries are fitted up with a power and a luxury of construction contrasting with the simplicity of English collieries.

In the Ruhr basin the thickness of the "morts-terrains" led before the Kind-Chaudron process, which has greatly reduced the uncertainty of sinkings, to the making of single shafts of large diameter. This is still done, though many of the fittings are double.

In all these basins the inclination of the measures being generally considerable, a large number of seams are worked from one pit by means of cross-cut galleries starting from it.

The number of shafts in one fitting varies much. In the Ruhr district, though most often the small concessions have only one shaft with compartments, there also occur some rather small concessions having several shafts for one complete fitting, close to concessions having only a single shaft, of large diameter it is true, and as powerfully fitted up as the most powerful English collieries. In the large concessions, one often enough finds, as at Westphalia Colliery, a double fitting, long the only centre of working in the property, then at 1000 or 2000 yards from the first fitting, another much more recent formed of a single shaft. This second centre, started usually from the profits realised by the first, is destined to be connected later on to the first; but it must remain independent during many years. In the Sarre district there is little regularity in the arrangement of the pits relatively to one another.

The extent of the field to be worked by each fitting is generally restricted enough if compared with what is the case in England. In the Ruhr, galleries across measures are frequently from 500 to

2000 yards long, and from these galleries levels from 900 to to 1500 yards may be driven. In the Sarre and in Lorraine the length of these roads is more limited.

The constitution of a colliery is not subject to any very exact rule. In the Ruhr district, a fitting very often consists of one single pit, which, after the lapse of many years, is put in communication with a second. The majority of the new collieries which are being sunk in the north-west, where the "morts-terrains" are thick, begin with a single shaft of 16ft. 5in. clear in diameter. In the Sarre a fitting is made up most often of an assemblage of pits (three to six), at little distance apart. In Lorraine a fitting consists always of two pits very close together, sometimes connected to a third acting a part more or less important in the ventilation of the works.

No legal nor special rule prescribes in Germany the number of orifices by which a mine must communicate with the surface, but in the Ruhr a tendency to make two orifices compulsory seemed to show itself among some of the members of the Oberbergamt.

Whatever the number of pits may be, the general organisation never has in Germany the uniformity that it has in England; each colliery differs from its neighbour. This is especially the case in the Ruhr; in the Sarre district there is a tendency to follow on the lines of the English arrangements; and lastly, in Lorraine the general organisation of the fittings is analogous to that in the North of France.

The relative position of the pits is not less varied than the manner in which they are organised.

The distance separating the pits of the same fitting is very variable, as will be seen further on by Table III. of the ventilation. In the Ruhr, this distance varies from 2,700 yards for single shafts, forming each a complete fitting to 40 or 60 yards for conjugate pits.

If, in the Ruhr, where the air current, after having circulated through the workings, always returns to its starting point, no importance seems to be attached to the separation and keeping at a distance of the upcast and downcast shafts, in the Sarre they seek to furnish to the return air means of escape more rationally spread over the stretch of the field of operations. It is true that

at Sarrebrück the absence of "morts-terrains" and the nature of the surface render very easy the sinking of pits and inclines in the seams.

The surface fittings of the collieries, very powerful and monumental in the large collieries got up twenty years ago in the Ruhr, tend to become simpler, while still keeping a large power, by the increasingly extensive use of iron for the head gear and landing stages. Not less monumental and perhaps more massive still in the Sarre, they are changing in the same direction as in the Ruhr, by a very extensive and well-imagined use of iron. The last fitting got up, that of Camphausen, is with that of Harris Navigation in Wales the most powerful seen by the commission, and it is not less simple.

Nowhere, in all these collieries, was it seen that any special precautions were taken to aid the air in entering the downcast; everywhere the air enters as it wishes—or more exactly, as it can. If, however, the masonry buildings which envelope the pit in the Ruhr seem established with no forethought on this point, the new fittings of the Sarre which leave the mouth of the pits absolutely free, appear much better imagined.

In furnace shafts they content themselves, as at Heinitz, by prolonging the walling of the pit by 12 to 20 yards, so as to form a chimney. At no place did the commission see coal drawn by a furnace pit.*

When coal is extracted by the upcast shaft, as the commission saw in two places, the pit mouth is closed by movable covers or bonnets. At Westphalia Colliery there is an ingenious arrangement for minimising the shock of the cage against the cover—a shock always prejudicial to the winding ropes, especially metallic ropes. An explanation of it would, however, demand too much space. M. Laigneaux, director of the Styring Collieries, has adopted at St. Charles No. 2 Pit the following simple arrangement:—Suppressing all the ingenious but very heavy details of the Briart cover, he has reduced it to a cover of $\frac{4}{5}$-in. pine planks, bound by two cross pieces of oak. This cover, extremely light, in spite of its dimensions of 10 ft. 6 ins. × 3 ft. 9 ins., is raised by

* While in Westphalia I met with two examples of this arrangement, near Gelsenkirchen.—J. H. R.

the end of the rope which strikes on an elastic cushion formed of a thick band of caoutchouc circling the very small opening through which the rope passes.

The form of the new pits in the Ruhr is circular, of a diameter often greater than 16 ft. 5 ins.; the old pits are rectangular, and, more exactly, having the sides arched from 16 ft. 6 ins. to 19 ft. 6 ins. in length, by 10 ft. to 16 ft. 6 ins. in width. In the Sarre the new pits are also round and of large diameter, 17 ft. 8 ins. at Camphausen. The old pits are nearly all rectangular with straight and arched sides of various dimensions. In Lorraine all the pits are round.

In place of the brick and cement tubbing which formerly obtained in the water bearing strata of the Ruhr the English metal tubbings or the cast-iron rings of the Kind-Chaudron system are now employed. In the coal strata they wall with brick, and, nowadays, the walling often consists of staves of wood 2 ins. thick kept in position by circles of iron placed inside at every mètre, as in Kaiserstuhl Pit at Westphalia Colliery. In the Sarre, the absence of "morts-terrains" dispenses with all tubbing, and the wallings are in wood in the old pits, in brick in the round and arch-sided pits, and in wood and iron, disposed as at Kaiserstuhl, in the new pit at Camphausen. In the upcast shaft of this colliery the wooden staves have been replaced by sheet-iron $\frac{1}{8}$-in. thick kept in position by inside circles of irons bound together by vertical pieces of iron assuring their distance apart. This constitutes a very clean lining, but one only applicable in ground naturally solid.

A pit is rarely used solely for one service; nearly always winding, pumping, and ladders, or a Fahrkunst, are found together in the same pit. This is particularly the case in the Ruhr, but in the Sarre and Lorraine the upcast is usually reserved as an air pit. Figs. 1 and 2 represent two of the pits visited by the commission, and show to what an extent at times the shafts are encumbered by the various divisions which are established for each service, whereas, in England, on the contrary, the section is always kept as free as possible.

In the pits, still so numerous in the Ruhr, which act at once both as downcast and upcast, the bratticing consists most gener-

ally of a simple partition of 1in. to 2in. oak planks nailed on the dividing buntons. Frequently, however, as one might expect in

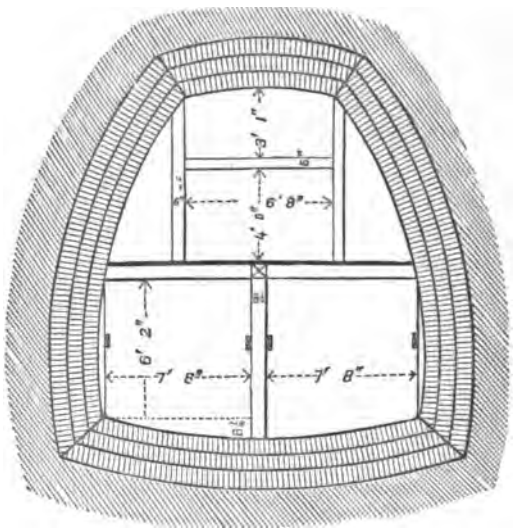


FIG. 1.—Arrangement of No. 4 Pit of Heinitz Winding and Downcast Pit, with compartment for lowering wood, &c.

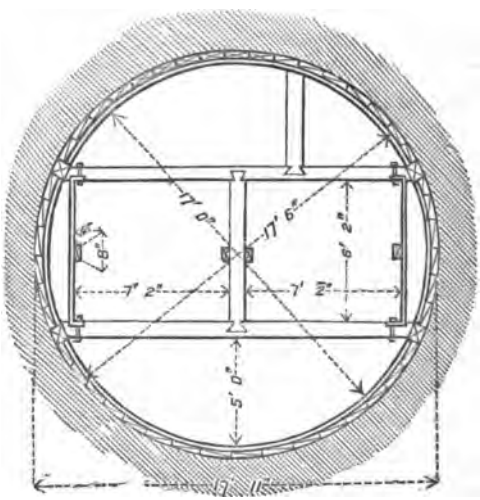


FIG. 2.—Arrangement of Winding Shaft of Camphausen—Downcast.

a country where the system is so largely used, more elaborate devices, some of which the commission describes, are employed for fixing and maintaining air-tight the bratticing.

In a general manner, the administration of mines seemed to abstain from interfering in the organisation of the shafts. It allows, without remark or any kind of restriction, new collieries with a single shaft to be formed; and one of its most authorised representatives mentioned to us as the most exemplary colliery, as regards ventilation, in the fiery district at the head of which he is placed, a colliery having only one shaft.

ARRANGEMENT OF UNDERGROUND WORKINGS.

Owing to the usually inclined position of the seams, their multiplicity and their closeness to one another, one fitting always works several seams simultaneously, often 5 to 6 at each side of the pits. Everywhere the general arrangement of the workings is as follows:—The pits being sunk in the middle of the group of seams to be worked, to a depth sufficient to give in the seams a lift (relevée) of 88 to 160 yards, two headings at least are driven from each side of the pit across measures, with a vertical distance between them of from 44 to 110 yards, and each constituting the basis of a working stage. The air generally enters by the lower cross-cut gallery and returns by the upper, after having circulated through the workings in the lift comprised between the two galleries. In the upper stage (*i.e.* in the workings to the rise of the upper gallery) the current which has aired it must often return, descending to the upper cross-cut gallery. The height of the workings to the rise of the upper gallery is generally very limited.

A pit in full activity generally comprises three stages, the lower stage in preparation, the middle stage in full work, and the upper nearly exhausted. The height of these stages, the vertical distance which separates two consecutive cross-cut galleries, varies very much. It is regulated according to the inclination of the seams so as to have normally between two stages, lifts of 55 to 165 yards, measured following the seam.

In the Ruhr, in those parts where the coal measures are covered by water-bearing "morts-terrains," a pillar of protection is left, a small part only of the upper stage being worked

out. This pillar, which is left intact between the water-bearing covering and the workings, was required by a decree of 19th June, 1846, to have a vertical height of 45·7 yards, but this height has been reduced to 22·85 yards by a new decree of 12th April, 1862.

When the lift in a stage is greater than 220 yards it is usually split up into smaller lifts or slices served by roads driven in the seam, or sometimes even by special cross-cut galleries forming so many sub-stages, distinct, as regards drawing and ventilation.

The regularity of the beds, marvellous in the Ruhr, and even so remarkable in the Sarre, joined to their relative closeness, allows of considerable productions, without going far from the pit. This gives rise to a horizontal development more rapid than the deepening of the pits. It is improbable that any pit in the Ruhr has yet reached 550 yards; in the Sarre, the deepest pit, Camphausen, was sunk at once to 559 yards. In Lorraine, irregularity and accidents in the measures lead to a more rapid deepening.

In short, the annual deepening of the pits, though more rapid than in England, is much slower than in Belgium; and at all events, the relatively feeble depth of the workings and the small quantity of fire-damp call for, in no part of Germany, precautions analogous to those required in the Borinage of Belgium.

From what precedes, one may gather that stonework, so exceptional in England, is very largely developed in Germany. The airing of these galleries, nearly always effected by means of pipes, is generally of a mediocre description, and would be absolutely inadmissable were fire-damp slightly abundant. Wooden bratticing and wall of brick are, however, being now used at Styring in Lorraine for airing galleries.

In general, each stage only comprises two cross-cut galleries at each side of the pit. These galleries, separated, as before stated, by a vertical height of from 44 to 110 yards, cut across the whole group of seams to be worked. Starting from these galleries, from each side or sometimes from one side only, horizontal galleries or levels are driven in the workable seams. To the rise of these galleries the working places, of which the disposition varies with the system adopted, are opened out. That is the plan constantly adopted in the Ruhr and Lorraine.

In some mines of the Sarre, and particularly at Heinitz, another plan is adopted. The field is divided for each stage into panels of 220 or 330 yards broad by parallel cross-cut galleries driven at a horizontal distance apart of 220 or 330 yards. Each seam is thus divided into so many distinct districts. These cross-cuts are connected among themselves and to the pits by large level drawing roads driven in the seam which has the best top and bottom, and in which, consequently, the upkeep of the galleries is the least burdensome.

This disposition has the advantage of considerably reducing the length of level driven to each side of the cross-cuts, and, consequently, the length required by the air current to travel in each district. The splitting of the air can thus be more fully carried out, and, as regards the working, if care be taken to drive all the cross-cut galleries of a stage simultaneously, a very large output per stage can be attained. This concentration of production can, in certain cases, compensate, as regards economy, for part of the outlay which such a development of stonework entails.

The Commission saw in no part of Germany the large sections that the English open for the intake and return air near the pits. This difference is justified by the considerable difference in the volumes of air entering German and English Mines.

The rule, in the best conducted mines, is always to prepare a stage in advance. For that, the pits are always sunk beforehand to at least the depth of a stage; starting from these pits a cross-cut gallery is driven from each side of the pits. Usually, at the same time that these galleries are being driven, dip roads are driven from the upper stage in the most suitable seam, and where, as at Heinitz, they are made long enough beforehand they allow of attacking the cross-cut galleries from both ends at once. At all events these dip roads allow of direct ventilation being established as soon as the cross-cut gallery strikes the seam in which the dip road is driven.

Most generally, the seams in a stage are worked in the same order in which they are struck by the cross-cut gallery. When the measures are little inclined, as at Gerhard Grube, the top seams are worked first, in all cases each seam is worked off from the top downwards.

When a workable seam is struck the first operation is to make a communication with the stage above by driving an inclined plane in the seam. This is sometimes done by driving from top and bottom simultaneously. The circulation being thus provided for, the bottom level is pushed on, and from it are started, in proportion as it advances and according to the system of working, walls or inclined planes which serve as starting points for the formation of pillars. Whatever be the system, the preparatory works always consist of a bottom level of exploration and of at least one inclined plane in the seam.

The distance to which the level gallery is pushed in advance of the ordinary workings is very variable. In the Ruhr, this distance is at least 330 yards, the distance between two consecutive inclined planes. In the Sarre the distance is generally less; yet in virgin districts, as at Camphausen pit, this level gallery is driven as much as 765 or 1094 yards ahead of the working places, as much to explore the position of the seams as to drain the fire-damp which they give off.

In the Ruhr these galleries are generally driven singly, 9 feet wide and 6 feet 6 inches high and aired by pipes forming part of the air circuit. The Commission saw galleries being driven thus at Kaiserstuhl, with a single line of wooden pipes, 12 inches by 7½ inches, resting about 33 yards back from the face, which was 330 yards from the cross-cut gallery. In the Sarre, these galleries are always driven double 15 to 22 yards apart, and connected every 22 or 33 yards; but to carry the air to the face from the last connecting road 11-inch pipes of sheet iron or zinc are

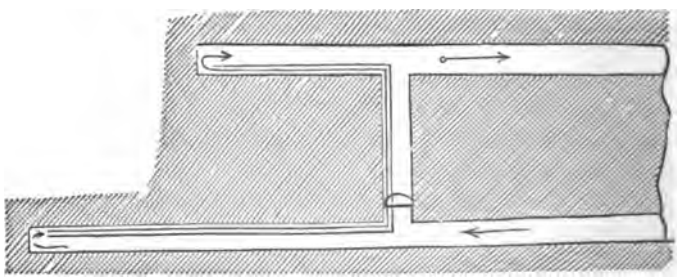


FIG. 3.—Airing of Galleries at Camphausen. Sucking and Blowing Pipes.

employed in one or other of the manners indicated in Figs. 3,

4, and 5. At Heinitz frequent use is made of small hand ventilators.

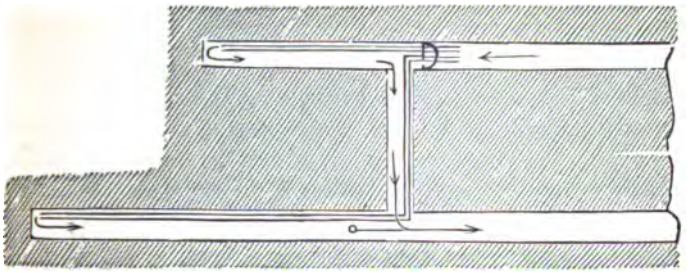


FIG. 4.—Airing of Galleries at Dudweiler. Blowing Pipes.

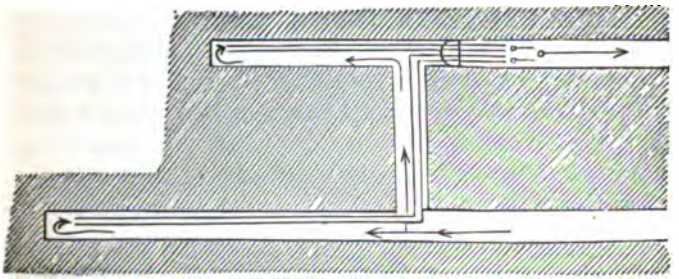


FIG. 5.—Airing of Galleries at Camphausen. Sucking Pipes.

These pipes, the use of which in Germany is greatly overdone, only give an air current generally trifling; the ventilation resulting is of the most uncertain kind, dependent as it is on the closing of doors by which workmen must constantly pass. Accidents from firedamp have more than once occurred in these preparatory workings.

The administration seems never in any way whatever to interfere in the conduct of those workings aired by pipes, save when hand ventilators are used as we shall see later on. The Commission is unable to state how the regulations on this point are observed, not having had the opportunity of seeing places aired by hand ventilators.

In the Sarre, the inclined planes in fiery seams are most often

driven downwards with the help of a compressed air winch, and are nearly always aired by pipes. At Camphausen, there was a dip road 410 yards long, aired thus by a single line of 11-inch pipes. This system, far from satisfactory, is often aided by a jet of compressed air led to the face. At Styring the dip roads with a total length of 110 yards are aired by simple diffusion, two distinct air-currents being observable, and revealed also by the dampness which covers the wood on its upper half whilst the under half remains absolutely dry. When the distance is greater than the foregoing and where firedamp is to be feared two parallel dip galleries 12 yards apart are driven simultaneously.

Everywhere, the first inclined plane driven in a seam is about 10 or 15 yards from the cross-cut gallery and parallel to it, thus leaving a pillar next the cross-cut.

Taken as a whole the workings of a stage are simply a repetition of what has been described for one seam in the stage.

Considering as a whole the system of ventilation we have the air which is led from the downcast along the cross-cut gallery at the bottom of the stage in point, being split up successively among the seams struck by this gallery, so that each one receives its own split of air to right and left of the cross-cut gallery. The air, after having travelled upwards through the workings, escapes into the upper cross-cut gallery, which being the main return leads it to the upcast. Any air leaking can only do so by passing through part of the workings, so that little loss occurs in this way. The ventilation in this system then depends exclusively on the style of its general distribution among the seams and on the manner of its detailed distribution throughout the workings of each seam. The latter point will be examined with the systems of working, but a glance will now be given to the former. The regulating doors for each seam are in Germany generally placed in the return airways close to the return cross-cut gallery, and generally it is by thus contracting the return gallery that the volume of air entering each district is regulated, as most frequently in Belgium and England. It seems preferable in fiery mines to reduce the section at the entrance to the district by acting on air still uncharged with firedamp. The choking of the upper part or outlet is liable, in fact, to cause accumulations

of firedamp. In workings where more than ordinary care is taken regarding the ventilation, as at Styring, the current is regulated at the entrance.†

Examples have already been mentioned of the large use made of air tubes; at L'Hôpital Pit, in Lorraine, for 18-inch galvanised iron tubes an excellent and speedily-made joint is used consisting of an indiarubber muff about 4 inches broad slipped over the joint.

Air crossings scarcely exist in Germany as the intake and return are always at different levels. The sections of the air galleries in Germany may be described, speaking generally, as comparable to those of Belgium and of France.

SYSTEMS OF WORKING.

All the systems of working which the Commission saw used in Germany may be classified under the following category :—

1. For seams of small and average thickness, the longwall system;
2. For seams of average thickness, the pillar and stall system;
3. For thick seams, the seam is split up, and each split worked longwall from bottom upwards with complete stowing.

Longwall.—This system with face going to the rise (tailles montantes), or level course (tailles chassantes), is applied to seams from 2½ to 10 feet thick, and inclined from 5 to 45 degrees. The dirt partings in these seams and cuttings from the roads supply a considerable quantity of stowing; but where that is wanting, as in certain seams of Albert-Schacht, spaces are left without scruple in the gob. At Sarrebrück, faces going to the rise are considered the more expensive, but a large output is more quickly obtained. The faces going in the direction of the strike give more economical results and better conditions for ventilation, but can only be set agoing on the completion of the inclined plane from each side of which they are started. Only two examples of longwall faces going to the rise (tailles montantes) were seen by the Commission, and as the general arrangement of

† *Note.*—This practice is prescribed in Austria.

these faces is, on the whole, identical with that in Belgium and in the north of France; it will suffice to glance rapidly at the points which may bear on the ventilation.

At Albert-Schacht pit at Sarrebrück, the distance comprised in one stage in a seam about 4 feet thick, and lying at 18 degrees, is 170 yards, the length of each wall is about 22 yards, and the distance of one in advance of another is from 8 to 10 yards. It is this passage from one wall to another, a passage never kept in more than moderate repair, which forms the weak point in this system as far as the ventilation is concerned. The ventilation of the quarter visited, where 13 walls start from the same level, consists of a single current rising by one side and descending by the other.

At Styring, where longwall with face going level course is adopted, rubbish is brought from the surface when necessary for complete stowing.

The air-current in the Sarrebrück Collieries often passes along the faces in a downward direction, but everywhere else it is ascensional. In Lorraine, there is always a distinct split for each set of walls at each side of the inclined plane forming the axis of the quarter; but, whereas at Styring no more than 8 or 10 walls are aired by the same current, at L'Hôpital the same current frequently passes round three successive sets of 10 or 12 walls. In the most fiery seams of the latter colliery the course of the current is limited to 10 or 12 walls, yet, in the upper walls firedamp is strongly indicated in the lamp during the bringing down of the coal. These seams are, in short, the most fiery which the Commission saw in Germany, and may be compared to the fiery seams of certain Belgian mines.

Pillar and Stall.—As this is by far the most general system of working in Germany, it may be worth describing at some length. In the mines visited by the Commission, it is used in three forms which differ completely by the way in which the panels, formed by the first general tracing, are worked out.

A.—In the first style the panels are split up into long pillars parallel to the level, a system applied to seams $2\frac{1}{2}'$ to $7'$ thick, inclined at from 10° to 73°, and giving no rubbish for stowing. This is the general system in the Ruhr Collieries, and in the

Sarre it is applied to some seams giving a little rubbish. This rubbish when used for building,—as further on we shall see it is,—while it ameliorates the general conditions of airing, dispenses with the necessity of leaving to the rise of each pillar during the stooping a strip of coal which protects each working place, but which gives rise to a loss of about 10% of the coal in the seam thus worked.‡

Fig. 6 represents the working in a seam at Westphalia Pit;

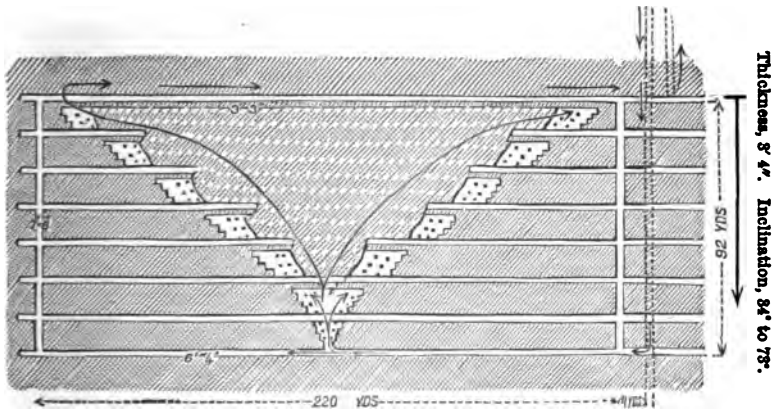


FIG. 6.—Mode of taking out the long pillars at Westphalia Colliery.

Fig. 7 represents the working of a seam at Heinitz in which the working place is protected and isolated from the gob by a wall of rubbish got from the seam.

The height of the panel is generally equal to the distance between two successive levels, and consequently varies much with the inclination of the seams, and in the collieries visited, varied from 60 to 160 yards. When the height of the panel is greater than 160 yards, it is sub-divided into two, or at times three, smaller

‡ In one of the largest collieries which I visited in Westphalia, the workmen were in the habit of putting a shot from time to time in this rib, and thus winning as much of it as possible. The ribs I saw were left of the same width as the thickness of the seam.—J. H. B.

panels which are worked out successively, beginning with the upmost.

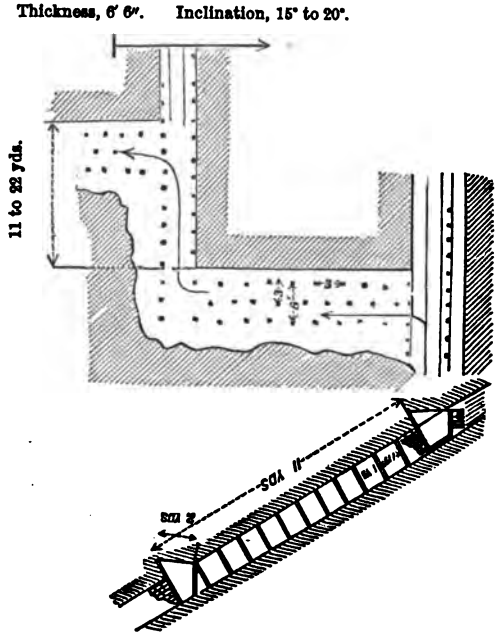


FIG. 7.—Mode of taking out the long pillars at Heinitz.

Fig. 8 shows the system of working and ventilation at Dudweiler, in the Sarre. The length of the panels is regulated by the nature of the surrounding rock: it varies from 220 to 330 yards. This being the distance between the planes, the roads which trace out the panels only go half the length.

The opening up of the panels is effected by roads driven from each side of the inclined plane parallel to the level, 1½ to 2 yards wide in the Ruhr, where there is no rubbish to dispose of, and in the Sarre where there is rubbish, of a width necessary to stow it. Where the seam affords no rubbish these parallel stalls are aired by means of communications put through the pillars when required.§ The width of the pillars varies from 10 to 16 yards.

§.—At Bonifacius Pit, in Westphalia, I saw air holes bored through the pillars every 20 or 30 yards for ventilation. The boring machine is driven by hand and makes a hole 12 inches in diameter.

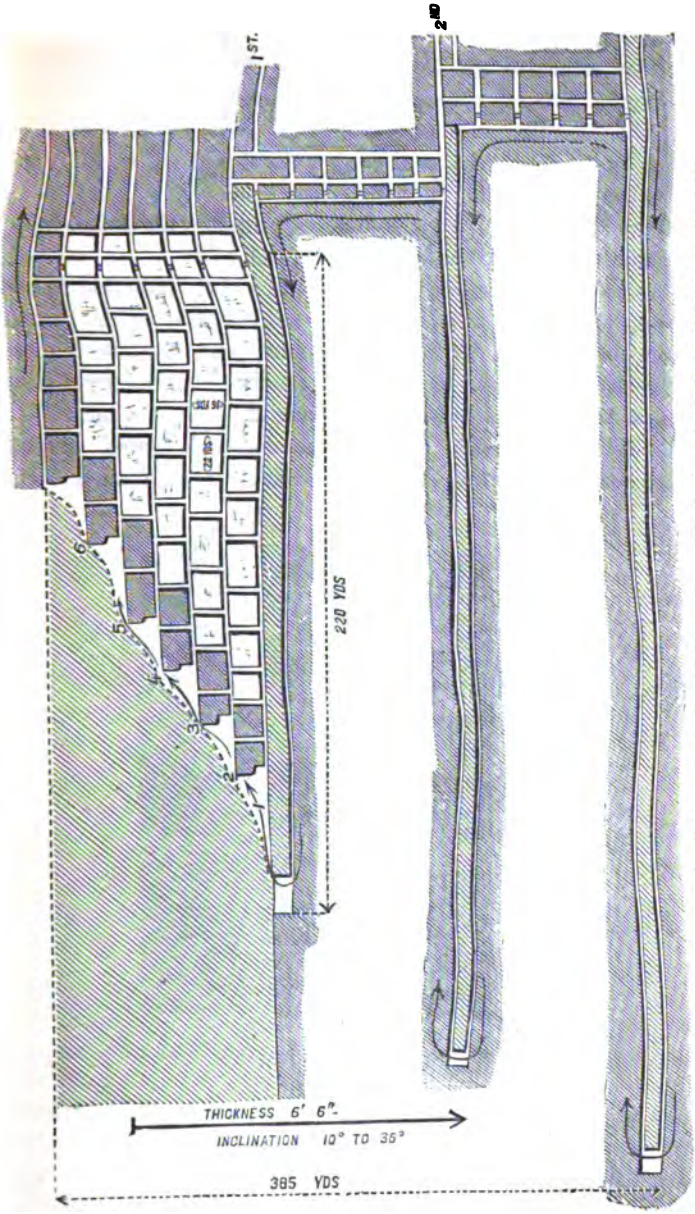


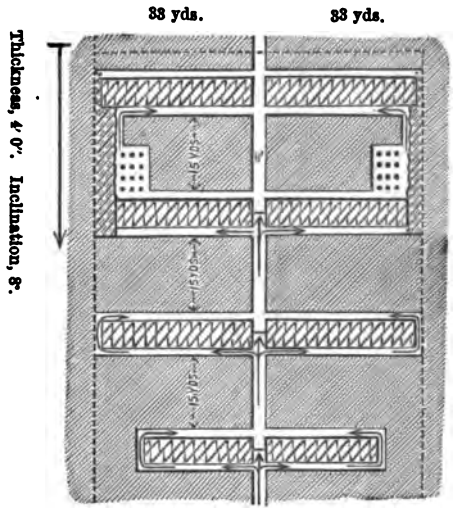
FIG. 8.—Arrangement of the Workings in the long pillar system at Dudweiler. The left subdivided into three slices.

The working off of the pillars is begun at the middle of the panel by attacking the top pillar and bringing it backwards towards the inclined planes in a zig-zag face (en rabattant) the height of the pillar, as shown in figures. When there is no stowing to build above the stall road, a rib of coal $2\frac{1}{2}'$ to $3\frac{1}{2}'$ is left at the top of the pillar.

Everywhere the propping is done very exactly, the timber being set about a yard apart and usually in three rows.

The course of the air current is sufficiently indicated in the figures, but it may be said that the air which reaches the bottom of the district in work all right, scarcely distributes itself there except by diffusion, in fact very irregularly; and the ventilation of these working places is of a middling enough character.

B.—The modification of the pillar and stall system adopted at Dorstfeld is shown in fig. 9, and needs little explanation. The



[FIG. 9.—Mode of working out pillars in the long-pillar system at Dorstfeld.

seam is 4′ thick, lying at an angle of 8°, contains some rubbish, and has a very bad roof which makes short panels necessary, and even then demands a large consumption of wood for the maintenance of stall roads. The bratticing for directing the course of the

air current is often defective, and from this cause and the falls from the roof the working places, which form veritable *culs de sac* are aired chiefly by diffusion.

C.—At Gerhard Grube and at Heinitz, in the Sarre, the system shown in Fig. 10 is adopted in seams from 5′ to 7′ thick, with an

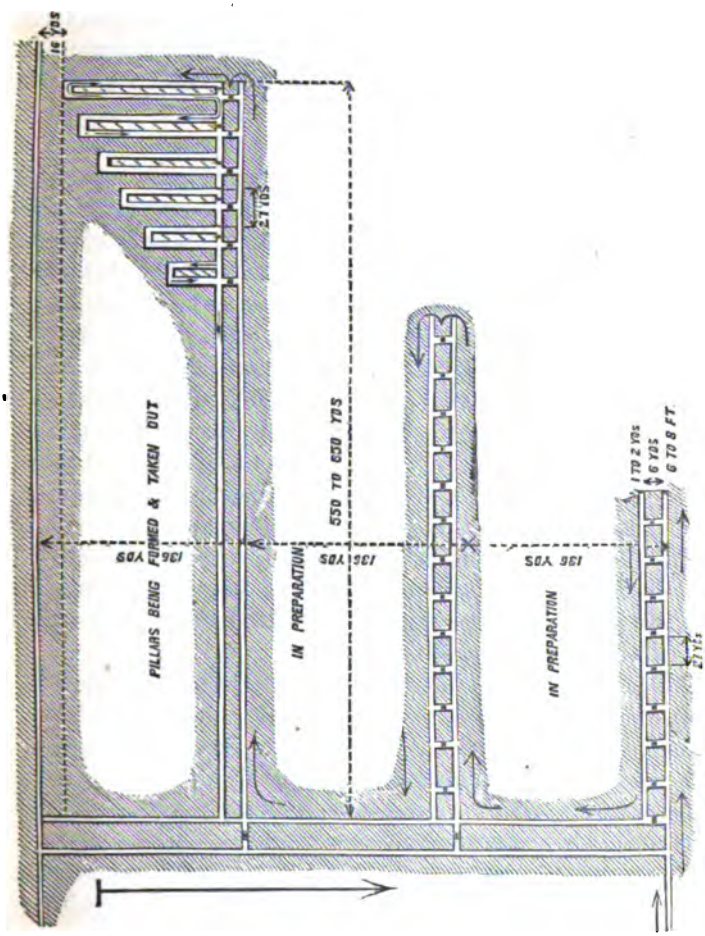


FIG. 10.—Arrangement of Workings in the long-pillar method of "Gerhard Grube," Seam Heinrich.

Thickness, 6′ 6″. Inclination, 8° to 11°.

inclination of 5° to 12°, containing a considerable quantity of rubbish, and having a pretty good roof. Each stall road is pro-

vided with a self-acting incline which is lengthened as the face advances. The pillars left between the wide stalls are taken out, beginning at the top, by successive slices of 2 or 3 yards wide where the seam gives no rubbish, and of 5 to 6 yards where rubbish is to be stowed.

This system of working, like the preceding, gives rise, all along the levels, to so many *culs de sac*, aired in a very average way by so many bends given to a general current, already very feeble through the imperfect stoppings.

The third method of working noted by the Commission, and the description of which I can only, for want of space, reproduce in the most general manner, is applied in Lorraine alone, at Styring in the seam Henri, 7 to 8½ yards thick, inclined from 17° to 20°. This seam is neatly divided into several beds by dirt partings, it is pretty fiery, and the coal heats rather freely.

The system, as it is applied at Wendel pit, consists in decomposing the seam into four parallel slices of equal thickness worked in succession from the bottom upwards. Each slice is worked by longwall, with the face going level course (tailles chassantes), and the vacancies in the gob filled with sand brought from the surface. The working of the four faces is carried on simultaneously, with this restriction, that the zig-zag line of faces of a lower slice is 16 or 17 yards in advance of that of the face immediately above. The ventilation is exclusively ascensional. As stated the seam is fiery and the following precautions are taken to render the ventilation as efficient as possible.

The number of walls in activity in one slice is limited to five, the stowing is made to follow the face very closely, and lastly, the largest volume of air is sent round the faces of the upmost slice where firedamp, from its small specific gravity, is most likely to accumulate.

AIRING AND VENTILATION.

The commission saw no example of a fiery mine aired by a natural current, but in the two districts of East and West of Dortmund there were said to be three pits aired in this way; they are free from gas, and there is cause to believe that some device, such as the heating of the column of air in the upcast shaft, stimulates the natural ventilation.

The following methods of producing artificial ventilation are employed :—(1) By putting the upcast in communication with the boiler chimney; (2) by furnaces; (3) by fans. The injection of steam for heating the upcast is a means also said to be employed in some pits of Westphalia.

It is at the pit Kaiserstuhl of the mine Westphalia, near Dortmund, that the commission saw the best example of ventilation produced by boiler chimneys. The Kaiserstuhl Pit has a single shaft, with compartments, and is 15 ft. in diameter, or 176·71 sq. ft. in section, of which 43 sq. ft. are reserved for the upcast compartment. The output per shift of 8 hours from a total depth of 243 yards is 350 tons; and only one stage of 70 yards vertical height is worked. The pit is quite new and passes for one of the most fiery in Westphalia. The boiler chimney, through which the return air passes, is 87 yds. high and 13 ft. in diameter at the base, and 12½ ft. at the top. The current obtained by this means is quite comparable to that obtained by ventilators in neighbouring collieries reputedly the best ventilated. The total volume of air measured at the bottom of the pit at the entrance to the upcast compartment, and which has nearly all circulated through the workings usefully, is 23,950 c. ft. per min. The W.G. produced in this mine having, unfortunately, not been taken, the equivalent orifice could not be calculated, which, from a theoretical point of view at least, deprives of much interest the relative results of this ventilation. This fitting is, however, only temporary, preparations being made at the time of the visit for the erection of a Pelzer fan.

In the new fittings all over Westphalia ventilators are now-a-days preferred to furnaces. Thus in the district of West Dortmund, among twenty collieries, two alone are ventilated by furnaces, and even one of these is being demolished.

In Sarrebrück also, ventilators have been adopted in the new fittings, such as those of Heinitz-Dechen and of Camphausen. The furnaces of Sarrebrück, which the commission examined, are fed with fresh air. That of Heinitz, represented in Fig. 11, has a surface of 24′ × 3′·98 = 95·5 sq. ft., and it is stoked at one of its long sides by means of six doors. The furnace is now fixed at a depth of 219 yards, and the return air enters the upcast

87 yards higher; but formerly the furnace was fixed on the same level as the return, and to keep separate for some distance the heated gases from the furnace and the return air current a brick partition was built on the upcast shaft. The height to which this division went is not mentioned.

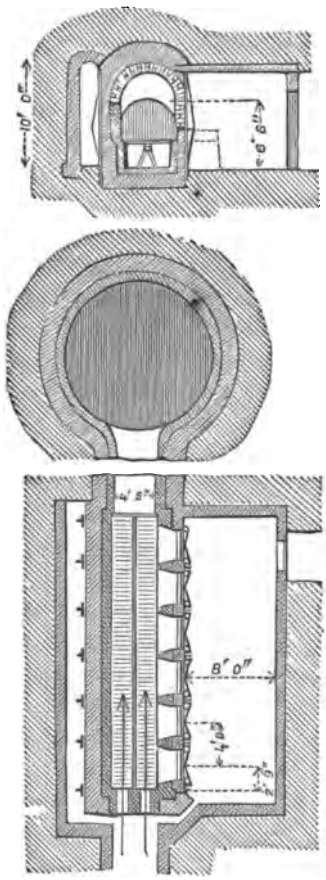


FIG. 11.—Furnace at Heinitz.

The fans of large diameter and of slow speed which are met with in Westphalia and Sarrebrück are all of the Guibal type. In the latter country no other types are used; in Westphalia, on the contrary, the tendency to-day is towards high speed fans of small diameter of different types, of which the most extensively used are the Winter and the Pelzer fans.

The Guibal fans in Westphalia and Sarrebrück have generally neither the sliding shutter nor the tips of their blades curved. The diameters vary, as in Belgium, from 23ft. for the oldest fans to 39·38ft. for the most recent, from 30 to 33ft. being the most usual diameter.

In Westphalia the Guibal fans only receive the air by one side. In the recent fittings of Heinitz and of Camphausen, the ventilators receive the air from both sides, and besides the whole envelope, as well as the chimney are of malleable iron. In these two fittings the English practice of having two machines, one being in reserve, has been adopted; they are fixed diagonally at an angle of 45°, thus occupying less space than usual.

At the colliery Gerhard-Prinz-Wilhelm, in Sarrebrück, there

are two 23ft. Guibal fans, the one exhausting from the other. Fig. 12 shows the most recent fitting, that destined to air the seams Heinrich, Carl, and Maria. This figure gives the plan of the general fitting and the longitudinal sections of the two fans. The air entering by the passages A B reaches fan C, from which it goes by the horizontal chimney D and the passage D E F into the fan G, which is an ordinary fan. K is a chimney which is opened when the fan C works alone. The sketch dispenses with the need of all other explanation: a glance shows how, by means of the doors P,P,′ and P″, the two fans can go together, or either of the two alone.

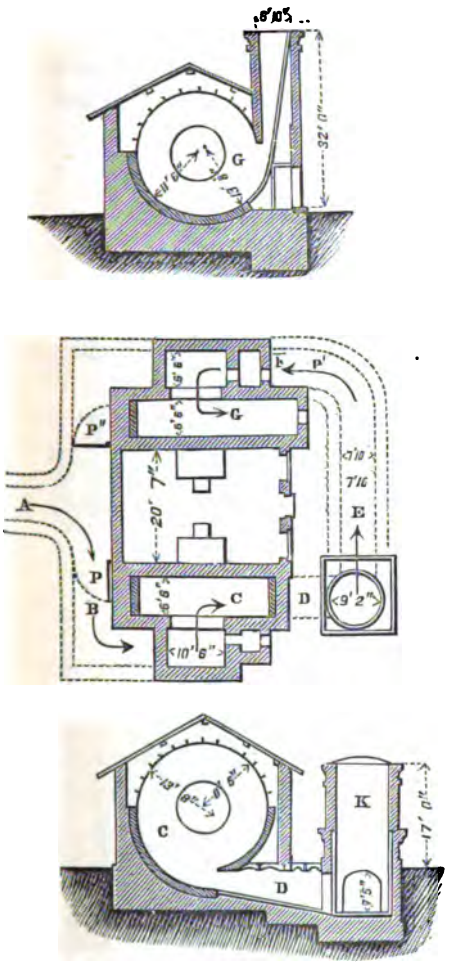


FIG. 12.—Guibal Fan, one exhausting from the other, at Gerhard Grube.

This fitting of two Guibal fans, one exhausting from the other, was not erected thus in the first instance. There had formerly been erected in these two points, as in several others of Sarrebrück, and as the commission saw in Belgium, two fans, of which one stood in reserve in case of damage to or derangement of the other. By the modification, simple and inexpensive enough, adopted to make one fan exhaust from the other, it has been possible to obtain a double water gauge, and, consequently, to increase the

volume of air in the proportion of $\sqrt{2}$ to 1—*i.e.*, by 41·4 %—t
by complying with the increased requirements of the working
utilising the old apparatus, in place of erecting others n
powerful.

Generally, the velocity at the periphery in the Guibal fans
Germany is less than that in Belgium and especially in Englar

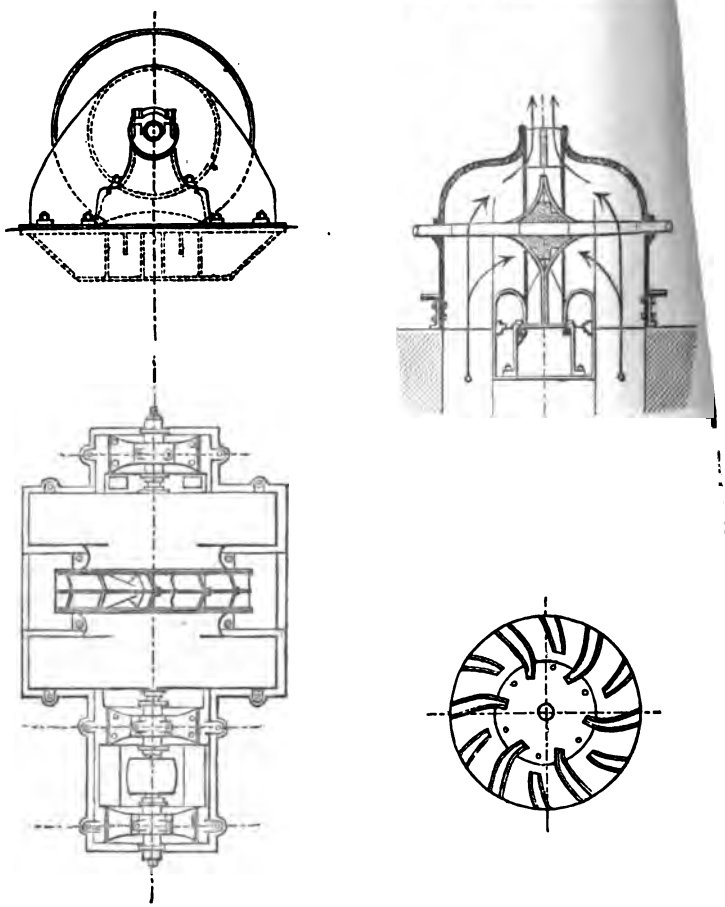


FIG. 13.—Winter Fan at Dorstfeld. Scale, 1-60th.

The Winter Fan (Fig. 13), as erected at Dorstfeld Colliery, near Dortmund, is a centrifugal fan ordinarily 5 ft. 3 ins. in

external diameter, and 11 ft. 8 ins. broad, with bent blades, receiving the air at the centre from both sides, and expelling it freely by the whole circumference. A fan of these dimensions usually makes 540 revolutions per minute: *i.e.*, has a velocity at the periphery of 148 ft. per second, but it can be increased to 700 revolutions or 192 ft. per second. These fans are always entirely constructed in wrought iron and turn in a cast-iron envelope.

In the Pelzer Fan it has been sought to combine the spiral with the centrifugal fan. It is composed of two parts as shown in Fig. 14. One part, to the front, facing the passage by which the air arrives, exhausts this air by a heliçöid movement; the back part next the open air constitutes a sort of moving diffuser, being fixed to the front part, and expels the air by the whole circumference as in the centrifugal fan. These apparatus, also made entirely of wrought and cast-iron, vary in diameter from 4 ft. to 9 ft. 10 ins., but most often have a diameter from 6 ft. 6 ins. to 8 ft. With this last size these fans make 250 to 300 revolutions: *i.e.*, an average velocity at the periphery of 115 ft. per second, but the speed can be increased to 400 revolutions per minute.

There is at present, in Westphalia, a very lively movement in favour of small diameter and high speed fans and against the Guibal Fan. The commission has thought it would be interesting to collect all the proper data for forming a correct idea on this question. To the details they themselves gathered at the collieries visited, which are given in Table III. are added in Table II. all the latest details on this subject they could gather from other sources.

These tables demonstrate at once the great superiority of the Guibal Fans over the others when considered merely as so many machines for the production of ventilation; that is to say, capable of giving the highest "manometric efficiency."‖

‖ The note given by the commission in explanation of this term is worthy of being reproduced in full, but I give the following note from Mr R. T. Moore's summary of the report of the same commission on Belgian mines:—If V represent the velocity of the periphery of a centrifugal fan, and gravity=32·2, then $\frac{V^2}{32 \cdot 2}$ is the highest possible depression it can produce. This is never got in practice but a certain fraction K $\frac{V^2}{32 \cdot 2}$, K is the manometric efficiency of the fan. They also further insist on this as the only rational basis for comparing fans, and state the fact of their having verified its utility for detecting defects in fans by several examples met with in Germany.

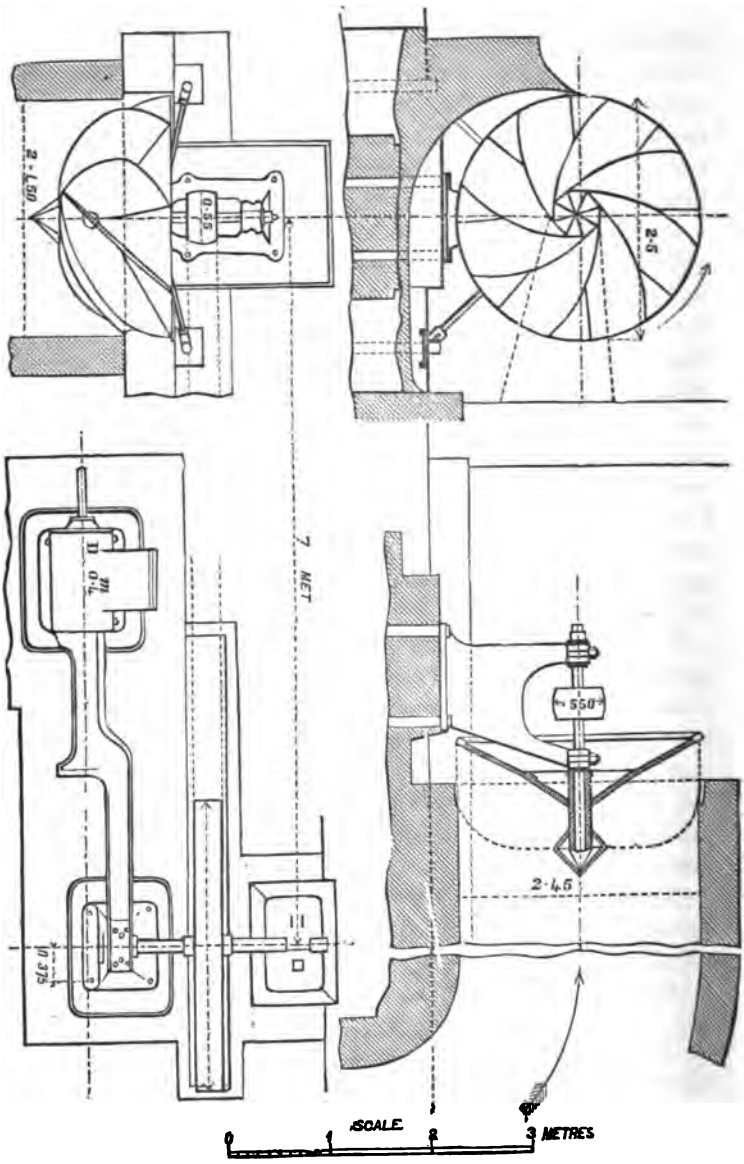


FIG. 14.—Pelzer Fan.

The average of 13 different Guibal Fans shows a manometric efficiency of 0·611—the highest being 0·728, and the lowest 0·447. On the contrary, all the small diameter high speed fans mentioned in the tables have never given a higher manometric efficiency than 0·3.

It is of essential importance to notice that except in experiment 32 of Table II., all these mines have a small or average equivalent orifice, more often small. As might be foreseen, as soon as the equivalent orifice increases, the manometric efficiency falls and even very rapidly, as No. 32 Table II. seems to show. The "characteristic curve" ¶ of these apparatus should tend more and more, as the equivalent orifice increases, to become parallel to the axis of the x's.

The favour which the small fans actually enjoy is based on the following motives; on the one hand, that their erection is much more rapid, easier, and more economical; and on the other, that their working efficiency** is very superior to that of the Guibal.

The first reason cannot be disputed. Again, a greater economy of steam may well influence the choice. The experiments 27 to 38 of Table II., and the calculations made from them, have been cited chiefly to justify this view. But these calculations cannot be accepted without question: the motive force has been valued not by diagrams but by taking the pressure indicated on the steam gauge at the boilers. In addition, the dimensions of the engines are too great and the speed of the fans too low to give satisfactory results: in other words, the fans and their machines are not suited to the conditions in which they are placed. A 40 ft. Guibal Fan to make a depression of less than an inch, and draw 36,000 cubic feet of air, fitted with a 76 H.P. engine, is hardly an economical arrangement.

¶ The characteristic curve of a fan here meant is that defined under this name by a Commission of the South-east district of the Société de l'Industrie minérale. A given fan turning with a certain velocity U at the periphery gives a W $G = K \frac{U^2}{32 \cdot 2}$ by which it produces in a mine with equivalent orifice A a certain volume V. For each value of A there will be a certain value of V, so that a curve having for abscissae the values of A and for ordinates those of V may be traced. This curve completely defines a fan in all the circumstances in which it may be placed. (Bulletin de la Société de l'Industrie minérale, 2 série, t. VII., p.p. 477 and 713.)

** By this is meant the proportion of the work required to circulate the air to the indicated work of the piston.

It appears from the details gathered, which, however, do not admit of drawing in all respects quite reliable conclusions, that the equivalent orifice†† of the Westphalian mines may be described as medium.‡‡

The mines of Sarrebrück have also medium equivalent orifices, though the seams worked are thicker. This essentially arises from the length and complication of the air passages.

In the following table is given the splits of air in the different quarters in Gerhard-Grube;—the quantities given in the table are those which actually reach each district, and are usefully employed.

Districts Ventilated.	Volume of Air in Cub. Feet per Min.	Number of Workmen in Largest Shift.	Daily Output in Tons.	Cubic feet of Air per Minute.		SEAMS.
				Per Workman.	Per Ton.	
	10,240	190	180	53	57	Beust Seam, South district.
II	13,320	140	150	95	89	Beust Seam, North district.
III	12,800	310	700	41	18	Carl and Heinrich Seams—Bottom Stage, North Side.
IV	3,180	100	200	32	16	Heinrich Seam—Bottom Stage, South Side.
V	3,180	150	175	22	18	Heinrich Seam—Upper Stage, South Side.
VI	9,520	50	75	190	127	Carl Seam—Upper Stage, North Side.

No systematic rule is followed in splitting the air in Germany and the principle is carried out to no great extent. The velocity, is never very high. It is quite the exception to find a velocity of about 13 feet per sec. in ordinary return galleries where there is generally no traffic, and in the workings it is rare to find veloci-

†† *Note.*—The notion of equivalent orifice, introduced by M. Murgue, and much used in France, is thus shortly described:—In a given mine if a certain depression h be produced, a determined volume V passes through it. The mine may be compared, as far as the resistance it offers to the passage of the air is concerned, to an orifice A in a thin plate through which this volume V will pass if the difference of pressures at the two sides of the opening be exactly equal to h. The section of this orifice in square feet affords a very simple method of characterising the mine from the point of view of ventilation.

‡‡ M. Murgue defines as a narrow mine one whose equivalent orifice is less than 10·76 sq. ft. (1 sq. metre); as a wide mine one whose equivalent orifice is greater than 10·76 sq. ft.; and as a medium mine one whose orifice ranges between 8 and 12 sq. ft.

ties greater than 3 feet per sec. It is probable that 5,400 yards in the seam Elise at Dorstfeld, and 4,400 yards in a district of Albert-Schacht are the greatest lengths to which the air-courses are ever carried.

There is no regulation on the subject of ascending ventilation. Nevertheless, in the Ruhr, the administration would authorise no prospective plan (Betriebsplan) in which the current was not ascensional as a whole. In narrow work, the colliery officials are left quite free to do as they choose, provided that the working be sufficiently aired. It has been prescribed by a circular of 17th July, 1879, from the Oberbergamt to the inspectors, that where hand-ventilators are employed, these must not be blowing but sucking or double-effect fans, and if the place be at all fiery, the air exhausted must be sent directly by tubes into the nearest return.

In the Sarre, general descending ventilation and currents following descending faces are allowed, as at Albert-Schacht.

For the control of the airing, no regulation obliges the engineers in the districts around Dortmund and Bonn to keep up special plans of the ventilation, but these are nevertheless met with in some mines of Westphalia and the Sarre. That seen at Dorstfeld, in Westphalia, indicated in a sufficient manner the distribution of the air, but was unaccompanied by a register of the ventilation. At Gerhard-Prinz-Wilhelm, both are kept very completely.

Neither is the measurement of the volumes of air obligatory, and it is of their free will that certain engineers make periodical measurements at different points in the pit. At Westphalia Pit the measurements are made in the main return cross-cut gallery, and behind each seam is a measuring station so as to determine successively by difference the volume passing through each seam. At all these stations the gallery is made regular, for a distance of 2 yards by planks nailed on the timbers. For making these measurements the Cassella anemometer is used, being placed at the centre of the gallery. At the fiery pit, Kaiserstuhl, M. Hilbeke, the director, has these measurements made every two days. At Albert-Schacht the measurements are found by placing the Cassella anemometer at the centre of the gallery and taking the mean of three trials, each lasting three minutes. This is done

once a month. These operations are generally made by the special fireman called Wetteraufseher. At Heinitz-Dechen, two employees, appointed exclusively for this work, take the measurements on the plan indicated by Mr Schondorff (Zeitschrifft für B.-H.-u-S.-Wesen, Vol. XXIV., p. 120), by simply observing the velocity at the centre, whence the mean velocity is deduced by multiplying the observed velocity by 0·75 in timbered roads, 0·80 in rock, and 0·85 in those which are walled.

All the fans seen by the Commission were provided with a water gauge, generally of the classic U shape; but at some of the Sarrebrück mines there is a registering apparatus in which a pencil traces a curve of the varying depression. None of the fan machines seen were provided with counters of the revolutions.

Observations of the barometer and thermometer are only obligatory in those Westphalian mines on which such a special rule has been imposed. Everywhere else the custom where once followed has fallen out of use. In those mines of Westphalia where special rules are laid down on this point, the director is counselled when a barometric depression occurs to exhort his firemen to greater vigilance. This is vague enough, and everything seems to point to an outward respect for the barometer without much faith in it.

ORGANISATION OF THE WORK AND THE SUPERVISION.

The organisation of the work is practically the same in Westphalia and in Sarrebrück. There are generally two shifts of eight hours in Westphalia, and of ten hours in Sarrebrück, one following the other without interruption. The morning shift, which is specially the coal shift, begins about five in Westphalia, and about six in Sarrebrück. The afternoon shift, which begins on the completion of the morning one, is almost entirely devoted to repairs. In the mines of the Moselle where the seams worked are thin, the two shifts are divided from one another by an interval.

The official staff is in its entirety nearly the same everywhere, save in some details of certain mines.

In each pit constituting a mine there is an Obersteiger who is the underground overman, and who receives his instructions for

the general guidance of the workings from the engineer, the Betriebsführer. In some mines with only one pit the Betriebsführer may act as Obersteiger; he is in this case more engineer than overman. The Betriebsführer may, as is generally the case in Westphalia, be subordinate to the true director whose orders he sees carried out. Nevertheless, it is the Betriebsführer who, in the formal terms of the law of 1865, is always considered as personally responsible. This is a situation which quite recals that of the "certificated managers" of England, and which always gives occasion in Westphalia to the same criticisms. It is found in law that the responsibility falls no longer on the one on whom, in fact, it really lies.§§

Under the Obersteiger are the Steigers (firemen), who have each under their supervision only one fixed part of the mine denominated Abtheilung. There is naturally a certain number of Steiger per shift.

Besides these officials there are employed nearly everywhere, to visit the working places, special workmen called Wettermänner. The Wetterman has no duties of supervision; he is a trustworthy workman to whom during the actual length of the shift an easy and remunerative work is given; he is nothing more during this time than an ordinary workman, and has no more to do with firedamp and ventilation than any other man. But he descends to go round a certain district so many hours before the other men, and he receives for this extra work extra pay, 1s 3d at Sarrebrück. The number of Wettermänner varies not only with the extent of the mine, but also with the danger it may present, and with the degree of vigilance exercised in the supervision.

In only one mine (Albert Schacht) did the Commission hear of a man being set aside specially for the supervision of the ventilation. This man, called Wetteraufseher, inspects the workings before the other workmen enter, as the Wettermänner do elsewhere, and during the shift examines at least once in detail the

§§ The responsibility of the Betriebsführer results from § 76 of the law of 1865, which has it:—"The persons who have undertaken the guidance or the supervision of the working are responsible for the execution of the plans, as well as for the observation of all the prescriptions and regulations contained in the law or made in virtue of this law."

whole district exclusively as regards the state of the ventilation. He has no direct authority over the workmen, but simply gives account to the Steiger or Obersteiger.

Besides, in the whole of Germany, in each working place with several workmen, one of them acts as chief. He is called by various names, and is the Compagniemann, the Vorhauer, or the Old Man of the Stall. He has an actual authority over his comrades, and possesses special functions in what concerns the supervision, firedamp, the inspection of the stall, the lighting, and the blasting.

For the inspection of the workings before the men enter, it is admitted, on the one hand that, where one shift follows another without an interval, no previous inspection is necessary: it is sufficient that the working places be visited during the shift by the inspector.

On the other hand, the inspection necessary when an interruption of work has occurred is of two kinds,—the inspection of the main roads, and that of the working places. The first is made by the Wettermänner, or Wetteraufseher, when they exist; the second devolves on the Compagniemann or Chief of the Stall. The Wettermänner descend alone into the mine two or three hours before the shift begins, and examine the main ways. Their visit made, they return to bank and give an account of their inspection to the Steiger who wait for them before proceeding to the roll-call, before which the workmen cannot enter the mine.

Throughout the whole of Germany it is the practice for the Steiger at the beginning and end of each shift to call the roll of all the men of his district in a special hall near the entrance to the mines.

In some mines the Wettermann leaves a mark of his visit at points agreed on. Should danger from any cause present itself in any part, he must bar the entrance to such part by hanging or nailing to a cross-bar of the timbering, a cross formed from two pieces of lath, which throughout Germany constitutes the recognised sign of danger, like the "board" of danger in England.

The roll called, and the men having gone down, the workmen of each place ought not, strictly speaking, to go beyond the point

where the Wettermänner stopped, generally indicated by a large cross chalk mark. From this point the Chief of the Stall makes an inspection before his comrades proceed further.

All the restrictions imposed by the special rules seemed, so far as could be judged from a rapid examination, to be followed out passably in practice.

In the districts visited by the Commission, it seemed as if they were not very particular in applying the principle that there should be no working in firedamp—that is, in a place where its presence in more or less quantity is shewn by the lamp. A perusal of the special rules shows that these documents accept that one may work with quantities of firedamp more or less feeble. They seem to provide that it is only on account of an accumulation relatively great that the Chief of the Stall or the firemen ought to stop or interdict work. That seemed to the Commission the way in which the rules were understood and applied. It saw several places where the men worked in gas. Thus, in one of the mines of Westphalia, which passes for the best conducted, a level in *cul-de-sac* was being driven where in the whole height of the road there was a cap on the flame $\frac{3}{5}$ in. long, and powder was even used for blasting in this road. It is said the working in the faces of this mine is often carried on in the presence of as much firedamp. In Sarrebrück it saw men working in a stall where the blue cap was $\frac{2}{5}$ in. on the floor, and where the lamp went out at the roof.

The readiness with which work is permitted in firedamp is cause for the greater astonishment that neither in Westphalia nor in Sarrebrück are met those conditions which in Belgium make work in firedamp a necessity, because there, in Belgium, even with the highest velocity admissable in a stall, it could not be cleared out. This was very far from being the case in the places to which allusion is made, where the ventilation, very sluggish, was almost effected by diffusion alone. It is only in the thin seams of Lorraine that firedamp appears in conditions recalling those of Belgium. Thus in one seam visited, where the face going level course comprised 12 successive walls, the firedamp showed itself at the fourth wall, and caused at the top wall a cap of $1\frac{1}{2}$in. to 2in.

In Westphalia the safety-lamps are nearly always a variety of the Belgian Boty lamp or English Clanny, generally called Westphalian lamp.

The Westphalian lamp (Fig. 15) differs from the Belgian Boty by having the part in brass between the glass and the oil reservoir pierced by three rows of small holes as in the lamps fed from below in England. In several mines the precaution of putting gauze behind these openings is not even taken; so that one too large might give rise to an explosion, as the commission saw by experiments made before it.

Herr Rosenkrantz of Dortmund, has modified the Westphalian lamp as represented in Fig. 16. There is at the under part

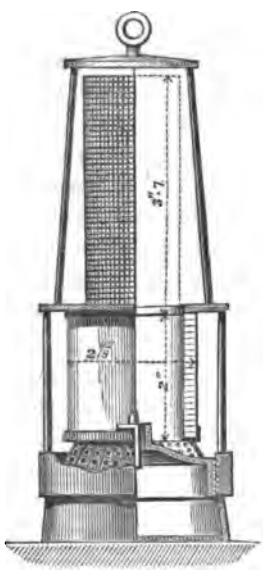


FIG. 15.—Westphalian Lamp.

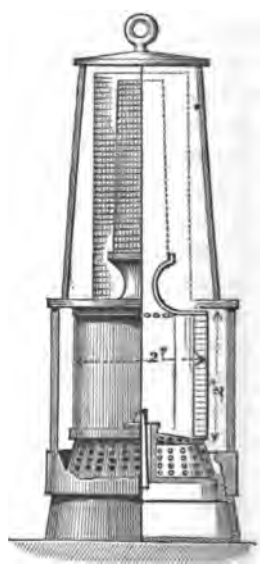


FIG. 16.—Rosenbrantz Lamp.

a double series of openings in a kind of air chamber formed by the mounting over the oil box. The gauze of the top part is double, the inner gauze forming a short central chimney by the brass mounting on which it is fixed. If the holes pierced in this

mounting were suppressed it would be really fed from below. This lamp, it is believed, has only as yet been used at Mansfeld Colliery.

In the Sarrebrück basin only the Belgian Boty lamp is used; in other words the Westphalian lamp, fed from below, has, not without reason, been suppressed. In the Moselle the Boty lamp and the Mueseler, practically of the regulation Belgium type, are used in the same mine. The lamps are usually locked by the ordinary screw and occasionally with a lead rivet.

The special rules of certain Westphalian mines require the exclusive use of safety lamps. More generally the choice of the lamp is left to the director of the works. As a matter of fact, both in Westphalia and Sarrebrück the safety lamp is used in a mine though it may be only slightly fiery, the naked lamp being used only in seams quite free from gas. Mixed lights seem to be voluntarily avoided though authorised by the rules.

Where mixed lights are used the only precaution imposed by the special rules is to mark by a large double white cross on the side of the road the points beyond which the naked lamps may not be carried.

In those mines of Lorraine where both Boty and Mueseler are used, the latter are used in the most fiery places, and the keeping unmixed of the two is left to the care of the men and the firemen.

The safety lamps are always kept, provided, and kept up at the lamp rooms of the mines; but at Sarrebrück the workmen buy their own lamps and pay for their upkeep in order to render them more careful. They can, however, only choose lamps of a fixed type, and it is believed the mine itself furnishes them generally. ||

Everywhere the lamps are numbered, and each miner has the same number as his lamp. In some mines of Sarrebrück and of Lorraine the miner on receiving his lamp gives in a check with the same number, which is hung on the hook from which his lamp was taken. A simple inspection of the shelves at once shows what men have entered the workings. Sometimes the workman receives his lamp locked at the lamp-room, sometimes he must

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|| It seemed the custom in the Westphalian mines which I visited to charge the miner 1d per day for oil.—J. H. R.

lock it himself with a key hanging in the hall. In the latter case it is always tried by the Steiger during the roll call.

For the relighting of extinguished lamps the ordinary practices are followed, without, however, exercising a very strict discipline in the measures adopted. Thus, at certain lamp stations, situated at times very far from the downcast and near enough the workings an open light rests. Besides, not only the firemen, but also the chiefs of the stalls are authorised to have keys and can open and relight the lamps where they judge they can do so without danger, even indeed in the stall itself.

THE USE OF POWDER.

It may be said that, in all the districts of Germany visited by the Commission, powder is freely used in the working of fiery mines, not only for stonework, but also in the seam. To interdict its use as certain special rules do "when the firedamp is disengaged 'strongly' ahead or in the immediate neighbourhood of the working place," is not, in truth, showing great rigour in the rules. Generally, the manager is free to say where it may or may not be used. The only precautionary measure prescribed, consists in an experienced workman making an examination of the place before a shot is fired. Should a certain accumulation of gas be discovered, certain special rules of Sarrebrück recommend the practice, so strongly condemned in France, of dispersing the firedamp by agitating the air.

DISCUSSION ON MR RONALDSON'S PAPER.

The PRESIDENT said this paper read by their young friend was a most valuable one, and it would, as usual, be reserved for discussion till another evening. Mr Ronaldson did not say what was the constitution of the Mining Board in the beginning. Did the original say so?

Mr RONALDSON—It consists of five or six members, who do nothing else.

The PRESIDENT said the paper would be printed and put into their hands, and, as it afforded so many materials for discussion,

he thought they might occupy two or three nights very profitably with it. The reference to the Wethermänner reminded him of how in the days prior to the present legislation the collier used to be paid 1s or 1s 6d more for looking the fiery parts of the mine. It was singular how they could recognise all the various officials in their own mines by all those different names. He could only add if they had enjoyed the paper as much as he had done they would be very much pleased. It seemed so freely written, and he had no doubt it carried the spirit of the original in it.

Mr DRINNAN, while expressing admiration for the paper, suggested that in future the Council relieve the author from the labour of reading a paper of this length, and arrange to hold it as read.

The PRESIDENT admitted that there was a good deal in what Mr Drinnan had said, but for his part he considered they could form a very much better idea of a paper from hearing it read than from merely reading it over afterwards.

DISCUSSION ON MR ROBSON'S PAPER.

The PRESIDENT next invited discussion on Mr Robson's paper on "Explosions of Firedamp."

Mr DRINNAN scarcely expected this paper would be reached at all that night, but there were one or two points in the paper he had marked. At p. 137, "The normal discharge" (reads). It seemed to him while reading this that it could have been put simply in this way: that the more feeders you lay bare the greater amount of gas you will get, because that was literally what it amounted to. Then at p. 139, "It has been noticed" (reads). Perhaps Mr Robson is right, but he (Mr Drinnan) had sometimes been inclined to wonder if that was not more due to the moisture of the air. He had observed it, mostly in England, that the roof fell in very hot weather. It became a very difficult thing to maintain their levels and principal roadways during some of the hot days, and he wondered whether or not the hot air coming in contact with the cold strata did not drop some of its moisture, and

in that way cause the roof to decrepidate or break down. Again at p. 141 he says: "Any system by which" (reads). I think it would have been well that he had stated what is the size of goaf that is to be left. Mr Robson was pretty well acquainted with the coal fields, he might say, throughout Scotland. Well, he might take some of the coal fields about Hamilton. He knew the strata above and below the coal, and he might give an opinion as to what size goaves in that field, or any other field with which he was acquainted in Scotland ought to be made, and that would be really some guidance to them. As it was it was really no guidance, because he did not tell them what was the proper size. At p. 145, he remarks, "There can be no doubt" (reads). Well, he would like to know from Mr Robson what were the conditions, apart from an accumulation of gas in which it would not be safe to fire a shot. Making an assertion of that kind without submitting the process of reasoning by which he arrived at that opinion, left the matter in a very vague state; and if he could do so, he thought it would be well for him to state what were the conditions, apart from an accumulation of gas, under which he would think it unsafe to fire a shot.

The PRESIDENT did not know if any of them had taken notice with reference to falling roofs with a low barometer, that supposing the barometer to be an inch lower they had a weight of over 600 lbs. on every square yard tending to bring down the strata. He often wondered if the collier, while working coal, ever noticed that the coal came down more easily when the barometer was low than when it was high. It was worth while noting that. There evidently was something in it.

With regard to a low barometer affecting firedamp, he thought the effect was very trifling indeed. Researches lately made in fire-damp showed this. In some of the English mines a bore-hole was driven some 30 feet into the coal, and a pressure gauge inserted. It was found that the pressure rose to 460 lbs. on the square inch. And while he thought it was very well to notice the barometer he did not think it was of so much importance as some people thought.

There was one point Mr Robson had omitted in his valuable paper. He alluded to those small explosions which constituted

by far the greatest cause of fatality in Scotch mining—a small explosion caused by an accumulation of fire damp, and which had come like "a thief in the night"—but caused no doubt by neglect. Probably it would have struck most of them who were in the habit of reading mining reports that collieries worked entirely with safety lamps were comparatively free from such explosions. Why, in the county of Durham, where there were 30,000,000 tons of coal produced annually, and where they had worked exclusively with safety lamps many a year, there was not a man burned. Here, where they had—of course keeping off those big explosions at Blantyre—comparatively small quantities of firedamp, every now and then they had one man killed, two men killed, three and four men killed or burned by explosions of firedamp in mines where they had been told that for months firedamp had never been seen. They had a complete cure for most of these small explosions in the use of the safety lamp. Of that there could be no doubt. In many cases—where there were quick currents of air—the safety lamp was not a reliable instrument, but the explosions he referred to did not happen under those circumstances. They happened where there was a small accumulation which might maim or kill men, and were caused, they might say, by neglect, but it might be as much by neglect to use an instrument which would protect them. To use a homely illustration, if a man carried an umbrella constantly in fair weather or foul, he would have the use of it when it rained. People might laugh at him doing so, but still he would have the best end of the stick if it rained. He was not going to say that every pit should have safety lamps and nothing else but safety lamps; probably that would be carrying the thing further than public opinion would take them, but it was very evident that if every pit were using safety lamps, and under proper supervision, they would have very few of those small explosions which were of such frequent occurrence. It was a matter to consider fairly. It had struck him during the reading of Mr Ronaldson's paper that it would be well to continue the discussion on Mr Robson's paper, or rather continue it with Mr Ronaldson's where it touched on the subject of ventilation.

Mr ROBSON, in reference to Mr Drinnan's remarks, rather

thought there might be something in what he said as to the moisture as well as the heat. He thought it was quite possible, because the two generally went together. He had noticed the effects in two or three places where the coal was very much wasted on the sides of the roads. He had also heard it stated, and there might be something it, that the roof had a tendency to fall during the night more than during the day. Whether the latter was caused by moisture or not he could not say; it could scarcely be the heat, because the intake air would be cooler during the night than during the day. As to the size of the goaves, he could only refer Mr Drinnan to the bottom of the page where he (Mr Robson) said as much as he would like to say. He must remind Mr Drinnan and the other members that he was dealing very generally with the matter. As to shot firing, he thought every man would find reasons why a shot ought not to be fired although gas had not been found. Conditions must crop up from time to time from careful examinations which would cause the fireman not to fire a shot. He thought there might be cases where gas, although not seen, was certain to exist.

Mr DRINNAN could not conceive the conditions that would render it unsafe to fire a shot if a careful fireman had previously examined all the places near to where the shot was to be fired. He could not conceive how there could be any danger of an explosion where there was no accumulation of gas. If the fireman was making a very careful examination, he could discover a very small quantity; and, if there were any wastes where gas could possibly have accumulated, he should be able to discover that. Though he had seen or known of places where it was ignited,—that was, the feeders,—he could not conceive of so much gas exuding at the time the shot was fired as to cause anything at all serious. It might ignite the feeders, but that was all the danger which could possibly exist, always supposing the fireman did his duty in examining thoroughly all the places near to where the shot was to be fired. He had certainly very little faith in the statements made with respect to blown-out shots causing an explosion, and he was doubtful whether it had ever occurred, or, if it had, he

believed it could be prevented by ordinary means. The raising of dust by it, he thought, might be prevented by watering the place. There was another point in Mr Robson's paper to which he wished to call attention, viz., at page 140, speaking of the velocity of the current, he says:—"The velocity of the air" (reads). Surely Mr Robson must be very well aware that an area of that kind was not often found in ordinary coal workings. He thought it would be a very difficult thing to maintain areas of such a size as that in ordinary coal workings. In some of the big coals about Hamilton it might be practicable and easy, but, as a rule, a much smaller air-way would have to do than that Mr Robson spoke of. "A high velocity being required in inclined workings" (reads). He would like to know why Mr Robson thought it necessary, in highly inclined seams, to have a higher volocity in order to dispel any firedamp which might be given off?

Mr Robson's reply was reserved, and the discussion adjourned till next month.

DISCUSSION ON MR M'CALLUM'S PAPER.

Mr M'CALLUM having now entered the meeting, the discussion on his paper, though it was near the hour for adjournment, was taken up.

Mr J. M. RONALDSON asked what was the meaning of the figures on the dial of the model produced?

Mr M'CALLUM said in their Niddrie Colliery the seam lay at an inclination of 60° or 1¾ to 1, and they brought up four hutches at a time on a carriage on rails, and of course these had loading seats. This (pointing) was the bottom loading of No. 1, 2, 3, and 4.

The PRESIDENT said the dip and rise was steeper than the roof of a house, and 1, 2, 3, and 4 were the different landings where they ran on the trucks. But the principal feature was that it was a sort of telegraph; to a certainty it pointed the same on the dial as at the other end. It rang the bell at both ends and obviated the necessity of a balance weight.

Mr GARDINER said at p. 133, Mr M'Callum stated that the signals could not be used for more that one bottom. He thought, by the simple addition of a cone placed behind the wheel that holds the chain, and by making a junction near to each bottom on to the main wire, it could be used quite well for any number.

The PRESIDENT suggested to Mr Gardiner that they should first discuss the propriety of adopting a signal like Mr M'Callum's without suggesting any improvement as to how it could be adopted for many places.

Mr GARDINER thought the principle a good one.

Mr DRINNAN, while wishing to compliment Mr M'Callum on the genius displayed in inventing this apparatus, and while he was inclined to admit that it might be entirely suitable for the special purpose for which it was designed, would be inclined to question whether it was adaptable for a road where tubs were being drawn for a considerable distance. Mr M'Callum said it was perfectly adaptable for that, and by an arrangement of levers at a few yards distance, it would be possible to give an instantaneous signal, and that this might be done by the lad springing off and pulling the lever. Now, when one considered the multiplicity of levers in a mile of road, placed say every 20 yards, they got an idea that there must be a great amount of friction, and he was doubtful if it would be possible to maintain those signals for a mile, or perhaps more—and it was not unusual in these days to have coal drawn that distance. He was further doubtful if an inspector would approve of any lad springing from his seat to pull the levers. It would be rather a dangerous practice. Independently of that altogether, however, placed at a distance of 20 yards, in a road a mile long, they would have nearly 90 levers. Well, that was a very great number of levers, and he was afraid, if it were tried, it would end in a very doubtful result.

Mr ANDERSON had been struck something in the same way as Mr Drinnan; but, supposing a signal given to the bottom, what was to bring it back into position, and make it ready for the next time? Was the lever attached to each wire alternately, or to one wire?

Mr M'CALLUM—Always to the one.

Mr ANDERSON—Suppose you make a bell to stop the engine, what puts it back into position? Is there a balance weight?

Mr M'CALLUM—No, you don't require that; you shift it before you go away.

Mr SHARP said he understood that at the Niddrie Colliery there were sometimes as many as ten or twelve landings.

Mr M'CALLUM—Yes.

Mr SHARP—You propose to have one for each landing?

Mr M'CALLUM—I must have according to Act of Parliament.

Mr SHARP—By the time you reach the top of the incline you have a great number of wires or chains—say about 20 or 30—all hanging with levers? A man would not know very well what one to catch?

Mr M'CALLUM—You have a separate signal for shaft work altogether in that case. The gentleman says he has a great objection to the levers for the weight. Well, if he has any objection to levers, a small clamp might be applied and there would be almost no weight or friction at all. It is a very easily wrought thing altogether. As to a man having to jump off the hutch to give the signal, he supposed in the electric signals they must get off the hutch.

The PRESIDENT—No; you have a piece of iron.

Mr M'CALLUM—In the case of a wreck, or the hutches geting off the road, the sooner the boys are off the train the better.

Mr SMART, to avoid the friction spoken of, asked if it would not do for the levers to be disconnected from the wire altogether, and to have some arrangement of a clutch the same as they had in above ground haulage to catch the wire.

Mr M'CALLUM said he had thought on this too, and it could very easily be done.

On the motion of the President, a hearty vote of thanks was given to Mr M'Callum for his attendance, and the discussion was adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 19th OCTOBER, 1882.

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

James S. Dixon, Esq., Vice-President, in the Chair.

Thirty-four members were present at the meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the Chairman.

The following Gentlemen were balloted for, and admitted as Ordinary Members:—

T. J. FOSTER, Editor of *Shenandoah Mining Journal*, Shenandoah, Pa., America.

ROBERT ROBSON, Manager, Breich Shale Pits, West Calder.

Other four gentlemen were then nominated for election, and will be balloted for at the first meeting.

DESCRIPTION OF WORKING SPLINT COAL BY "BACK SPLINTING."

BY MR W. S. RUSSELL.

In commencing to describe the working out of the Splint coal at Annandale Colliery, in Ayrshire, it might be as well to give the

names of the seams of coal met with there, and the names of the corresponding seams met with in Lanarkshire. We find the

M'Naught	Coal	=	Upper	Coal in Lanarkshire.
Tourha'	do.	=	Ell	do.
Major	do.	=	Pyotshaw	do.
Main	do.	=	Main	do.
Ladyhall	do.	=	Humph	do.
Splint	do.	=	Splint	do.
Turf	do.	=	Virgin	do.
Ell	do.	=	Virtuewell	do.

The Splint coal seam of Annandale Colliery appears to be in the same position as that of Lanarkshire, and averages from 3 ft. to 3½ ft. in thickness. It is separated from the Turf coal by about 13 ins. of stone. Sometimes the stone increases in thickness to 9 ft. between the two coals, but at the present workings of the Turf coal it is only 13 ins. The Turf seam is composed of 23 ins. of breast coal, 11 ins. of stone, then bottom coal 22 ins., with a daugh holing 1 in. thick, which give the working a thickness of nearly 5 ft.

The Turf coal is worked out on the long-wall system, with generally two levels—a high one and low one—the branches being put off the high one. When these branches had reached their destination, the usual practice was to work out the Splint coal by the process known as back-splinting—that is, to take out the Splint coal on both sides of the Turf coal road, taking between 3 and 4 yards of a coal face across the top of the pack wall, repeating it alternately till the excavation was about 10 yards from the level road—this 10 yards being left as a stoop to protect it. In working it out in this way, there was always a good deal of coal lost: as in the working from the side of the Turf coal road, across the top of the pack wall, they only took the hard portion of the seam with them, leaving the waterleaf or top ply of Splint coal, which is 11 ins. thick, for a roof supported by props. Then in coming back these props were drawn out when the waterleaf ply came down, and, as the clay is very brittle, the result was the coal was buried by it.

Seeing the amount of coal which was lost, caused me to try a ew method for winning out the Splint coal, viz., by going up the

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branch of the Turf coal level about 12 yards, then starting a level in the Splint coal to run parallel to the Turf coal levels, branching off roads in the Splint coal level on the top of the pack walls, then working the coal forward in the same method as the Turf coal. The workmen work off the clay from the top of the Splint coal, and build it in pack walls on the sides of their road, then lift the Splint coal in the same fashion as if it were an opencast working, obtaining good round coal with a very small percentage of dross.

The ventilation by the first method of working out the coal was always getting out of order, as the places closed in working back the Splint coal; whereas, now the ventilation is good and easily kept, as it goes up the old Turf coal roads and round the working face, then down the roads in the Splint coal, or *vice-versa*, as the case may be.

This system of winning out the Splint coal could be made applicable in many parts of Lanarkshire, *e.g.*, where the Virgin coal is about 33 ins. in thickness, with from 12 to 18 ins. of stone between it and the Splint coal, by working out the Virgin coal long-wall when the stone between it and the Splint coal would do to build pack walls under the Splint coal, then working out the Splint coal by the method I have described.

The CHAIRMAN supposed they would hold this paper over for discussion till next meeting. He thought it was a very useful paper, being just one of the subjects they were glad to get information upon. Mr Ronaldson had suggested if they could get a comparison of costs it would be a very good thing. It came to that in the long-run. On the Chairman's call, a hearty vote of thanks was accorded to Mr Russell for his paper.

MR M'CALLUM'S PAPER.

The CHAIRMAN resumed the discussion on Mr M'Callum's paper, descriptive of his new system of signalling. His own idea of this signal was, that it was an admirable thing for the place in which it was intended to work—viz., the Niddrie Collieries, where the seams were very steep—an angle of 70°,—and where,

instead of pits, the coal is drawn up in those seams from a great depth and from a great many different levels on the same incline. For that purpose, and to overcome the disadvantage pointed out of a great weight of ropes or wires this was an admirable invention. He did not agree with Mr M'Callum altogether in his strictures on the electric signalling. He might say that, in this district, since the men had got into the way of working them, they had got to a degree of perfection that could scarcely be excelled.

Mr M'CALLUM said he had had very little experience in electric telegraphy in mines, although he had had some little experience of it above ground, but he might say if they were getting them to work perfectly in the Hamilton district, they could not get them to work in the Niddrie district. He had had men employed two or three days contending with one between the Edinburgh office and the colliery office, and he found that a practical man connected with the North British Railway found a great difficulty in finding out what was wrong with it. There were a few strictures at last meeting in regard to his signal. Their friend, Mr Drinnan, had great objections to the levers which he (the speaker) proposed to apply in haulage. Well, he did not think this was a very momentous obstacle. Although he did not claim that the signal acted with anything like the instantaneous delivery of the electric signal, at the same time it was pretty near it. He was working with it now about 250 fathoms, and he found it to work splendidly. He was only working it from one bottom, but it could be perfectly easily applied to more than one, and if it could be wrought from six, seven, or eight different levels without any great amount of risk to life or accident, there could be no objection to it.

Mr ANDERSON thought this plan which Mr M'Callum proposed for avoiding friction by putting in that rocking centre instead of the small pulley wheels was a very good idea. He thought there would be far less friction in that than in going over small wheels. In regard to the haulage roads, they were not all straight, although they worked best when they were straight. There were a great many in the Hamilton district,—at least, he knew of some,—that were not straight. How would these signals

work in going round a curve? It seemed to be very well adapted for a straight line, but in a haulage road 700 or 800 fathoms long, with two or three curves going nearly at a right angle, how did Mr M'Callum propose to carry this round such curves to avoid friction, and make it easily pulled at the same time? Would the weight of wire that had to be moved in going round those curves not make it a very difficult thing to pull the wire quickly enough? Say there were 700 or 800 fathoms attached to it, it might possibly be done easily enough round one curve, but he would rather think it would be difficult to move such a length of it going round a number—three, four, or more curves. He knew a place where there were four, and nearly at a right angle on the haulage road.

Mr M'CALLUM said the way he would propose in going round a right angle would be a crank lying upon its side, and that would do for a break in the wire as well. In a slight curve, a side pulley would do very well. There would be a little friction, but he did not think it would interfere very much with the working of the signal. It was a straight line he had. He had a number of pulleys in, and he scarcely found any friction at all. A small steel wire was all that was required, and they had no weight to bring back.

Mr DRINNAN said that any objections he had to Mr M'Callum's mode of signalling were pretty fully stated at last meeting, and he must say, he had modified some of the objections he had after the statements that Mr M'Callum had made with respect to the mode in which he would attach levers or means by which anybody would take hold to pull it. He was influenced a little also by the fact that Mr M'Callum was working the signal at the present time, very perfectly, some 250 fathoms. He must, however, remember this was a short distance as compared with the great distances coal was hauled now-a-days in some of their important coalfields. Distances of a mile and more were not uncommon, and he would take objection to it until he saw it applied to distances of a mile. By putting up a crank where there was a right angle, there would be much less friction than passing it round pulleys, but there would still be a certain amount of friction in the turning of the crank, and at slight bends where he used pul-

leys. He thought Mr M'Callum would be well not to speak too positively of his signal being likely to be a success until he saw it tried in distances of a mile or thereabouts, because this was really the test whether it was at all likely to hold its own with the electric signal or supersede it altogether. It would only be after it was tested in that way that they could say much about it.

Mr M'CALLUM believed the electric signal was certainly the best for long distances for delivering messages, if he could get into the secret of keeping it in efficient order. There was, in the first place, a good deal of expense in connection with the erection of electrical apparatus, and there were many collieries, he believed, quite unable in the meantime to lay out that expense; and, in the second place, they had not all such ingenious men as they had about Hamilton. (Laughter.) He believed the atmosphere had a certain effect on it, and he did not think it was in the power of man to obviate that difficulty. He did not know whether it might take the same effect in the Hamilton district—(laughter)—but it certainly did at Niddrie. Mr Drinnan was, he believed, justified in saying if they went a mile or a mile and a-half they must require more leverage than he was working with just now. As they went out, they must have friction, and when they went out that distance, it would be heavier to work than in the meantime. He was certainly much obliged for the criticism, because it was only by such means that they could attain to perfection in anything. (Hear, hear.)

Mr R. T. MOORE—What would be the weight of a mile of wire for this signal?

Mr M'CALLUM—I could not say at present.

Mr MOORE—Is the wire of the thickness of that on the model.

Mr M'CALLUM—No, you require to use a thicker wire than that—about an eight of an inch.

Mr MOORE—The weight of a mile of that would not be very great, and the friction would not be any great thing in drawing a mile of such wire.

Mr M'CALLUM—Especially on a level road.

Mr JOHN WARDLAW—Has Mr M'Callum any doubt that it could be wrought easily at a mile from the experience he has

already had of the signal? As regards the weight of the wire, one mile of galvanised signal cord $\frac{1}{8}$" thick weighs nearly two cwts.

Mr MOORE—Would it be necessary to use such a heavy wire as that?

Mr M'CALLUM would not have any fear of the signal not working a mile. They could have a single wire instead of a strand, and he believed it would do the work perfectly well.

The SECRETARY said Mr M'Callum appeared to have been very unfortunate in getting his electric signals fitted up, and thought they were more expensive than the signal under discussion. If that was so he (Mr Gilchrist) thought he was labouring under a great mistake, for an electric signal, he was sure, could be fitted up cheaper than this signal here. In fitting up Mr M'Callum's system two wires were used, and to meet objections raised by some members, he proposed to connect the wires, say every 20 yards with an iron lever or rocking centre, so fitted that the signal could be made either way, and then drawn back into position for a fresh signal. In fitting up the electric signals two wires are also used, but they are much lighter and would cost less. An insulator is required, say every 15 yards, but it would also cost very much less than the iron lever spoken of. Both systems required bells, and for the electric signals a battery is used, but the battery would cost less than the indicator shown. Of course there was this, they had not the return signal that this one had, but a return signal could be made if wanted with the electric signals. As to its requiring skilled labour, it was just about a twelvemonth since we fitted up electric signals. He had seen electric signals working, but never had anything to do with them. In taking estimates for the material, he made arrangements for getting a practical man for fitting them up. However, there was some little difficulty—the party who supplied the material could not get the man at the time, so they started the foreman joiner, and he fitted up one small bell in the workshop. They then started below ground, and fitted them up in the whole of the roadways, and up to the present state, they had only

required a skilled man for one day. At that time they did not understand the great necessity of keeping everything clean. They thoroughly understood that now.

Mr M'CALLUM—We consulted electric engineers to fit up the electric signal at Niddrie, and found it would take £35 or £40. The cost of his signal bore no comparison with that certainly.

Mr SHARPE believed when they pitted Mr M'Callum's signal against the electric signal they took him off his ground altogether. From his (the speaker's) experience of edge working for some considerable time—he had charge of the work next Mr M'Callum's—they found great difficulty in working the original signal owing to the steepness of the metals. Mr M'Callum had, no doubt, experienced the same difficulty—hence the invention; and he looked upon this signal as one perfect for what it was intended, viz., an incline from two to six hundred fathoms long. Where there was no need for the electric signal at all, this was the best thing he had heard of; but he thought there was no use of putting it against the electric signals, because they would go into places that that signal could not go into.

Mr DRINNAN did not know how far it was correct to say they were taking Mr M'Callum out of his right ground, because Mr M'Callum himself pitted his signal against the electric signal. He thought they were quite right therefore, in comparing it with that. Looking to the remarks of the Secretary with respect to the cost, he had been thinking of another idea regarding the electric signal, viz., the cost of keeping it in repair. Mr M'Callum might be perfectly right in maintaining that the cost of keeping the electric signal in repair would exceed the cost of keeping up his signal. Perhaps Mr Gilchrist would be able to give them an idea of the cost of maintaining the electric signal. He had had some little experience of it in England, and he knew that very frequently a man was required to attend to the battery. There was not a great deal of expense, but it was incurred every two or three months, and there was great difficulty experienced in finding out what was wrong. He thought at the time the man, the engine-wright, had a very imperfect knowledge of the signal itself and how to keep it in order.

The SECRETARY was not prepared to give the cost of keeping

up the electric signals, but said the cost was trifling, and, he thought, would compare favourably with Mr M'Callum's system, for his signal wire would be much heavier, and there would always be a severe strain on the wires, which would tend to break them. They all could speak from experience on that point.

Mr ANDERSON had heard recently of a battery that had been working for six months and never caused any trouble nor any expense. He thought this was a thing that would obtain all round. At Auchinraith, they had had them for fully five years, and he just knew they were in the pit. Mr M'Callum had referred to the great expense in keeping them up. It was not their experience, and he agreed with the remarks of Mr Gilchrist. It was his opinion also, as to the wires of Mr M'Callum's signal, that they would be more liable to go wrong and cause a greater expense than the renewal of the battery, and the first cost would also be in favour of the electric battery.

The SECRETARY said it was four months since one of their batteries at Earnock had been renewed. One was renewed that week, but it was six months since it was put in. Then there were only some two or three cells for nearly three-quarters of a mile of wire.

Mr M'CALLUM asked Mr Gilchrist if he was working with two wires or a single wire.

The SECRETARY—We have two wires.

Mr M'CALLUM—Then, I suppose, according to the paper read here lately, you will have these wires to keep clean two or three times a week.

The SECRETARY said that owing to the relay battery recently introduced they could work the main wires with a much feebler current, and the wires gave them no trouble.

The CHAIRMAN supposed this discussion might be considered at an end. He thought they had exhausted the subject. If any one studied that very valuable paper by Mr Irvine, lately read before the Institute, he would not have much difficulty. At Bent they had great difficulty in working them for some months, but they had got over it. He thought a most important point in regard to Mr M'Callum's signal was that it was a return signal from top to bottom, so that the bottomer on giving the signal knew exactly what the engineman had heard. He thought this was a very

valuable apparatus, and for the purposes of a straight, long incline, it was a very good invention indeed. He thought they ought to give Mr M'Callum a very hearty vote of thanks for bringing it before them. (Applause.)

DISCUSSION OF MR ROBSON'S PAPER ON EXPLOSIONS OF FIRE-DAMP.

The CHAIRMAN, in introducing the discussion of Mr Robson's paper, said he was sure they would all agree that Mr Robson had given them a great many valuable suggestions and laid down the chief points to be noticed in conducting fiery collieries.

The SECRETARY read the following communication from

Mr A. GARDINER—I did not intend to take part in the discussion on this paper, at the same time I consider it only a duty to challenge any vague and loose expressions that appear in the Transactions, as they are read and reference made to them in kindred Institutes in England. The part I particularly refer to commences at midway down page 136 to end of the paragraph on the next page. "Fire-damp is not a purely elementary gas," and so on. The text of the paper has a tendency to convey a wrong impression of the constituent parts, as well as the characteristic points, when mechanically mixed with other gases. Fire-damp is the popular name of a compound gas known to scientific men as carburetted hydrogen gas (CH_4), also known by the appellation of marsh gas, from the fact that it is being generated and continually given off in marshy places. It is a compound gas, and is composed of two elementary gases—carbon and hydrogen—four parts of hydrogen (H) in chemical combination with one part of carbon (C). It is both the richest and lightest of the hydro-carbon compounds. Until recently, it was known as one of six permanent gases having conformed with Boyle's law of expansion and contraction. Being generated along with various other gases in the formation of coal, as free nitrogen, carbonic acid, carbonic oxide, olefiant, and sulphuretted hydrogen gases; it is mixed less or more with each and all of them in the same manner as sand and mud are

mixed in water in a river in time of a flood, viz., in suspension. It is generally known to all our members the difficulty it is to get very pure water, particularly those who have steam boilers under their charge, at the same time no one surely would say in defining water generally that it was composed of sulphates and carbonates of lime and iron, &c., besides hydrogen and oxygen; yet, many waters contain these and more compounds mechanically mixed. Steam is the compound gas of water, and is composed of hydrogen 2 parts to 1 part of oxygen (H_2O). Fire-damp is very inflammable, but does not support combustion; but when brought into contact with oxygen, which is one of the constituent parts of the atmosphere, complete combustion is effected, when 1 part of (CH_4) is mixed with 2 of oxygen, or what is the same thing, 9½ times its volume of atmospheric air; but this explosive mixture is interfered with in a decided manner with presence of either free nitrogen or carbonic acid. Sir H. Davy found that seven parts of explosive mixture with one part of (CO_2) carbonic acid added was rendered non-explosive; and one part of free nitrogen added to six parts of explosive mixture had the same effect. (See pages 172, 173, Thomas on coal mine gases.)

Again, at the top of page 139, in reference to the supposed effect of meteorological influences. "Main intakes sometimes crack and splinter off during very hot weather." The following is from observations taken in a tropical climate, when such, if they exist in a demonstrative form, would be more easily discerned than in our temperate climate of Scotland or even England.

In the sun, - - - - - - - -	145° to 160°.
In the shade, - - - - - - -	90° to 100°.
At pit bottom (70 yards deep), - - -	87° to 88°.
Natural temperature of coal, - - -	86½°.

There was a daily variation of over 60° many a time, and never less than 40° above ground, and no splintering effects were noticed. It will be observed that the daily variation of that country far exceeds the daily variation of this country; yet, to effect a variation below ground would require a much wider range of temperature above ground than that quoted. I am not aware of any statistics given anywhere of the expansion of coal; but from personal observations I am aware of bituminous coal (*i.e.*,

coal with about 40 per cent. of volatile matter) expanding when exposed to a temperature of 1000° Fah. Again, he states further down the same page—"In like manner the gases contained in the coal are expanded," and so on. I would be obliged to the writer of the paper if he can give some data on this point, as I have devoted some labour making out calculations relating to the work done or able to be done, by the lime process of getting coal. The same difficulty presents itself to me here, to find the power required to break down the coal. For example, take range of temperature at 60° (which really does not exist), the increase of volume due to increased temperature (60°) is as 1057·1 is to 1179·6, or expressed in lbs. per inch pressure, we have only 1¼ lbs. (taking the expansive force of air the same as steam). Now, gentlemen, if such small pressure produced by such extreme variation of temperature have effect on the stoops as inferred by the writer of the paper, the lime process of getting coal is a valuable acquisition in the getting of coal.

I will pass silently over the following pages, although much could be said on several points, to 144, No. 8—"Insufficient Ventilation." Under this heading our bold, intrepid author shrinks not from the point of defining a very knotty question, which has caused many of our eminent authorities to be careful in what they penned and stated, and even then, shrouded these over by their reasonings, which contain many conditions, leaving their statements very cloudy and, in fact, serve as texts for the practical man to be continually studying. I might here enumerate a few names and their ideas of sufficient ventilation. (See Fairley, M.E., on ventilation.) Mr H. Mackworth says, 100 cubic feet (non-fiery mines) per minute, per head; Mr Hedley, from 100 to 500 cubic feet per minute, per head; Mr Blackwell, from 250 to 500 cubic feet per minute, per head; Mr Dunn says that the minimum quantity should be from 10,000 to 15,000 cubic feet per minute in even a harmless pit; Mr Taylor, from 170 to 230 cubic feet per minute, per man (non-fiery); Professor Philips (fiery mines), 600 cubic feet per minute, per man, and 200 cubic feet per acre of waste. Here I have given an abstract of the quantities only, the conditions I have left out, but I give one for example:—Mr Smyth says, "We

should need at the very least 30 times that amount (200 cubic feet) of fresh air to dilute it, or 6000 cubic feet in addition." In defence of the author it may be said he gives no figures, and has therefore not committed himself. If I have a thin seam working, say 30in. high, and giving off gas, and I have 10,000 cubic feet of air per minute sweeping round the faces, but I have only an average of 66 cubic feet per head, and have no cases of explosions; have I, or have I not, a sufficient quantity of air? Again, take this other case (I am sorry I cannot give the figures so accurately as the foregoing one):—While working as a common "jack" in Ayrshire, in a pit under the management of a respectable old man, now deceased, father of one of our members, and belonging to Messrs Merry and Cuninghame, I had a narrow escape from being burned, by a slight explosion in a main air course. I cannot give the quantity of air passing at the time; but I have no doubt in looking back on the time that it was considerably over 66 cubic feet per minute, per head, and further, it was considered by the workmen in the district to be a well-aired and sufficiently-ventilated pit. If these two cases are to be weighed in and judged by this "fair definition," I fear the latter one would be found wanting and condemned as being insufficiently ventilated; whereas, the opposite is the case without the slightest doubt. The former case is one that requires the greatest care and watchfulness. Now, gentlemen, I have dwelt long enough, and trust, endeavoured in such lucid manner by applying observations personally made, to show conclusively the stumblingblocks that exist between the theorist and practical man. Colliery managers in charge of fiery mines are continually blamed —and may be often rightly—as a rule, by people that know little of the circumstances attending the manifold duties they have to transact, besides the responsibility of often thoughtless under officials. But, with all that, we in Scotland have the consolation that the inspectors are gentlemen of extensive practical knowledge and are well fitted to form a correct judgment on such points that attend explosions, to enable them to judge whether or not negligence can be imputed to the management. In conclusion, I have to offer my humble thanks to the author of the paper for the opportunity afforded for recording the foregoing on

ventilation, as I have long considered the subject of dealing with amounts of air passing through a mine no true test of the sufficiency or non-sufficiency of the ventilation. There is the height of workings—Is it long-wall or stoop-and-room? Is it well stowed or packed in buildings? What kind of stoppings are used? Are there many trap doors? And a host of little things well known to be under the immediate care of under hands. Although, at the same time, a good system of ventilation has just a minimum amount of these drawbacks, for drawbacks they are, if a large waste is to be contended with; such, and all of them, have a depreciating tendency of the real value of a large air current through a pit.

Mr ROBSON said perhaps he had better reply now to Mr Drinnan's remarks made at last meeting. With regard to the section of airways, while admitting that there was difficulty in certain cases of maintaining a section of 50 feet, it seemed to him that, in the majority of instances, the difficulties were not such as to render the size an impracticable one. Where this was so, and it was soon found out, he saw nothing but an increased number of airways so that the velocity in each might be kept within reasonable limits, because really it is the velocity which tells so rapidly in the economy of ventilation. As to the other query:—Perhaps Mr Drinnan had not been in highly inclined seams producing fire-damp, and it might be necessary to inform him that as the gas would lie at the face unless the current were strong enough to sweep it out, it might require a larger quantity of air and, of course, a higher velocity, in order to keep the face clear of any accumulation.

Mr DRINNAN had no wish to prolong the argument with Mr Robson with regard to the points he had noticed, but there was another point he drew attention to which Mr Robson had not replied to—at least, at any length—and it was a subject to which he attached a good deal of importance, viz., would Mr Robson state how it might possibly be unsafe to fire a shot where gas had not been discovered? Now, he thought this was a subject that was worthy the attention of this Institute. It was a matter of great importance, because there were many men of the present day who were inclined to advocate that the use of powder should

be altogether discontinued in their mines. Now, if this Institute either tacitly or otherwise agreed with Mr Robson, what position did they put those advocates in? Why, they put them in this position that they were able to say, here were the members of the Mining Institute of Scotland, which embraced nearly all the mining managers and the wisdom of the mining profession, and they had tacitly agreed that where a fireman could not discover the smallest quantity of gas, it would be unsafe to fire a shot. How could those of them who still believed the use of powder a necessity, then maintain their position? Why, the argument was gone! He submitted they had not a leg to stand on, and they could not then have any excuse at all for continuing to blast with powder. This was why he so strongly urged the point.

The SECRETARY might say he entirely agreed with Mr Drinnan in his remarks. In reading over the paper this was a point that struck him as one that ought to have been very clearly stated, for if they agreed with Mr Robson in this paragraph they put the management to a certain extent into the hands of the fireman. The rules were so clearly laid down that every careful fireman knew what to do. He believed it was the desire of the members that the firemen should read those papers, but if a fireman were to say, "Well, I don't find any gas, but I will not fire a shot," this would be an awkward thing. The manager should decide this. He thought Mr Robson should state the conditions more distinctly than he had done.

Mr BARROWMAN, without discussing the merits of the particular question that was before them, felt inclined to demur to the statement that Mr Drinnan had made to the effect that, when a statement made by a member was not questioned, therefore they as an Institute tacitly concurred in it, and he thought that the rules of the Institute bore him out in this. They stated that the Institute was not as a body responsible for the facts and opinions that might be held and the discussions that might take place in the Institute.

Mr ANDERSON would agree with Mr Drinnan in asking Mr Robson to define very particularly what were the conditions under which it would be unsafe to fire a shot when the fireman had not got gas in the place or the places contiguous to it. They some-

times came across places where the fireman had made an examination and could not see any gas. There might be a cavity in the roof at a short distance, but which he could not get into. There might be places where there were cracks in the roof not very far away. He did not know whether it was these Mr Robson referred to or not, but if it was a case of that kind he thought it would be well they should have a distance stated. How far back were those cracks to be from the place where the shot was to be fired? It would place them in a considerable dilemma if the fireman said, "Here is an opinion expressed by one of the members of the Institute, and I am going to guide my actions by that," and, as one gentleman said, refused to fire the shot. Some person in authority would either have to put another man in his place or do it himself.

Mr ROBSON, in reply, said that he agreed with those members who had taken part in the discussion as to the importance of the point raised. Mr Anderson had stated an instance where it would be better that no shots should be fired although the fireman did not discover gas, and there were other cases. Take, for example, a long-wall working, where the first ply of roof, having a good parting above, tended to bend down over the buildings and "cundies" as the face advanced. Now, if there was a seam of coal above this, or any strong bed which did not usually follow quick enough, but left a vacancy between the beds, and if the seam or roof produced gas, nothing would be more likely than that gas would lie in this vacancy. Or, take another case, where the roof had fallen so closely at the mouth of the cundy, or other waste, that air could not reach behind the fall. Now, in such like places it was quite possible that a careful inspection might fail to find gas, and especially so where the ventilation was good, yet it was not unreasonable to suppose that gas might be lying in dangerous proximity to the face of the coal or brushing. In his opinion there could be no doubt that explosions had been caused by shots dislodging gas where the inspection had failed to detect its presence, and hence the necessity for the utmost care being taken where there was a probability of such a thing happening.

The CHAIRMAN said what Mr Robson stated very much

amounted to this: the fireman was a man of skill and was to have a certain amount of discretionary power. That very much placed them in the position they were now in, for if the fireman thought the place dangerous he probably would not fire the shot. He had been struck the same way as Mr Drinnan. It looked like placing them in a dilemma.

Mr DRINNAN thought an important end had been gained by the raising of this point. Mr Robson had now stated what were the conditions which, in his opinion, might make it dangerous for a fireman to fire a shot. He must say he did not agree with him,—at least, he agreed a very little way with him with regard to the nature of the conditions he had stated, because he thought it would be quite possible to discover gas in any holes in the roof where there was an accumulation. It was not difficult to stick a lamp on the end of a stick and put it up where the height of the cavity was such that it could not be otherwise reached. This was always done in England. Mr Barrowman had said that he demurred to his (Mr Drinnan's) holding the Institute responsible for any statements that were made by any member of the Institute, whether in a paper or verbally. Well, he knew very well nobody could hold them strictly responsible for them,—that was, if they were called to account by anybody for certain statements made, they could wriggle out of it by saying "You see our rules; we don't hold ourselves responsible"—but then everybody who read the Transactions of the Institute, he hoped, held them to be intelligent men who, when a paper was read, either coincided with the opinions contained in it, or differed from them. He expected that members of other Institutes would look upon them in that way. He would be sorry to think that they did not; they would have a poor opinion of them otherwise, and that was why he was anxious members should express their opinions freely and frankly on any question that might arise.

The CHAIRMAN said Mr Robson had made a sketch which explained one position of matters which Mr Drinnan had not alluded to, viz., the cavity between two plies of roof. They could not get a lamp up there, and the shot might dislodge gas from that.

The SECRETARY—If Mr Robson's remarks applied only to places where gas had been frequently found, he would not, he

supposed, expect a fireman to refuse to fire a shot in a district, or section where gas had never been found?

Mr DRINNAN—The flame produced by explosion of a shot could not reach gas where the Chairman supposes it to be. I have known shots to light a feeder, but gas was present at the moment of explosion.

Mr ROBSON would not like to be in a place himself under the conditions he had referred to, if a shot were fired.

Mr ANDERSON—It appears Mr Robson's remarks are for exceptional circumstances.

The CHAIRMAN—Quite so.

Mr ANDERSON was prepared to agree with him if that were so. He had seen conditions under which he would not have allowed a shot to be fired somewhat similar to those although gas had not been seen for months. As to Mr Drinnan's mode of putting up a lamp on the top of a stick, he did not know if that would permit of general application. He had seen many falls come down, and that recently, where the break had been as if it were built in, and where there was scarcely room to put up a lamp the length of his arm. Mr Drinnan's question and remarks had served an important end in bringing out what were the conditions under which Mr Robson thought it unsafe to fire a shot where gas had not been seen.

Mr BARROWMAN said in looking at the actual words used it appeared to him Mr Robson's meaning perhaps might be conveyed in a way which would be satisfactory to the members generally if the word "many" were away. His words were "yet there will be many cases where." He thought the idea would be better expressed if the word "many" were omitted.

Mr M'CALLUM was sorry to say he had not read Mr Robson's paper so perfectly perhaps as he should have done, but he understood him to have said that cases might happen where it would not be safe to fire a shot, but he did not say if the fireman did not find fire there that he should not fire a shot.

Mr DRINNAN—Yes.

Mr M'CALLUM—In the hurried glance I got of the paper, I must have mistaken Mr Robson's meaning, for, on looking at the point in dispute, I find he says "That there may be

many cases where, although gas may not have been actually found, it would be unsafe to fire a shot." It was a fact that there were places often found proven not to be safe to fire a shot in, though gas had not been found by the fireman. He remembered a case many years ago in a work he was connected with in the Glasgow district. They were driving into the Splint and Humph seams and he thought, although he did not exactly remember at this date, that there were about three or four fathoms between the positions of these seams. They happened to be baring a march line and a "vees" at the same time, and the mode they adopted was to carry a road about 9 feet from the rib-side to return the air to the "cube." At the same time, they always left a cundy about 3 feet wide along the rib-side to carry away any gas which might be accumulated there. In the Humph coal there was scarcely any gas to be seen at any time, but in the Splint coal there was sometimes a large quantity. The faces of the two seams were going about parallel to one another. One day there were three men employed redding out a new cundy and stowing up the old one behind, back from the face about 9 or 10 yards, when an explosion took place. They were working with safety lamps, and it could not be conceived for some time what had been the cause of the explosion; but on further examination it was thought that a small quantity of gas had ascended up through the "vees" from the Splint coal to the Humph coal, and that the man working there had fired the gas through the firing of his shot or otherwise, and sent it down through the "vees" to the Splint coal. Now, any fireman would have said there was no danger in firing this shot in the Humph coal as no gas could be detected there. He thought that although there were careful observations there might be gas as in this case. He did not understand Mr Robson to say they were not entitled to fire a shot when gas could not be found, nor could he see how any man could say so. They had the Act to guide them, and so long as they conducted their operations within the meaning of that Act, they are quite entitled to fire a shot where gas had not been found happen what might.

The CHAIRMAN—The accident was one that would not often occur. There might be circumstances in which, supposing no gas

was found, it would be unsafe to fire a shot. He could say that as a general rule where a fireman did not find gas he was entitled to fire a shot. There might be instances where that was not the case. There was one point in Mr Robson's paper in regard to the coal splintering off in hot weather. He had noticed this particularly of late. In the month of August last there was a week or ten days of very hot weather. He found, and on asking others they corroborated, that from the expansion of the coal strata there was a considerable movement going on. It was a thing that required to be watched, since such a movement, if once set agoing, might require much expense to stop it.

The SECRETARY stated that he had also noticed the coal splintering off in hot weather. Earnock Colliery was started in the beginning of the year 1880, the roads were driven in a considerable distance in six or seven months, and it came on very hot, and there was a general movement over the whole pit. The rooms were well cut, a considerable quantity of coal came splintering off. At this time the bottom stoops were not all turned. The men noticed it as if it had been a "creep." If stoops had been in process of removal they would have said it was a "creep."

The CHAIRMAN thought it would be well to adjourn the discussion on Mr Robson's paper and go on with the

DISCUSSION OF MR J. H. RONALDSON'S PAPER.

Mr Ronaldson's paper, the CHAIRMAN said, was very interesting, and he was obliged to him for the trouble he had taken in dissecting the report by the French gentlemen, and giving the Institute the benefit of their researches. Both this paper and the former one were invaluable, and he would be very glad to hear any remarks on the subject. It appeared to him that on many points the German system of mining was inferior to that of this country, and apparently this remark applied also to France. To ventilate driving places by pipes seemed a bad point. One thing struck him as remarkable in this and the previous paper. These people seemed to be continually working in fire-damp. If we were in such places we would run to the pit bottom. They had always blue flame in their lamps. It seemed to be the regular thing. It was extraordinary that they had not more accidents than they had.

A MEMBER—Want of air. (Laughter.)

Mr R. T. MOORE, in reply to a member, said that the reason why they could not get the theoretical water-gauge as obtained from the formula to agree with that given in the table, was that h was the depression in feet of an air column, and in order to bring this to inches of a water column it must be multiplied by 12, and divided by 800.

Mr J. H. RONALDSON called attention to the following, referred to in his paper:—

At page 157, eighth line from the bottom, place "," after "footing." P. 161, about the middle, there is "88 to 160 yards two headings are driven." By "headings" are meant what we call level mines cross-cut. P. 171, under wood-cut, for "left sub-divided" it should read "lift sub-divided." P. 176, near bottom, for "machines" read "engines." P. 179, first line, for "11 feet 8 inches" read "11·8 inches." P. 186, sixth line, for "Vorhauer" read "Fahrhauer." Table II., in observed W.-G. column, second line for "3·22" read "2·32." In answer to questions asked by Mr Moore as to the officials in the mines, he explained, as follows:—

Betriebsführer (engineer) attends a School of Mines, and must pass an examination to get a certificate as Betriebsführer. He only goes underground in exceptional cases—as when an accident or such like occurs—and he is responsible to the Oberbergamt for all accidents. He does not attend to mercantile affairs at all. He has 1000 thalers (£150) a-year, and free house—*i.e.*, no house tax to pay (most of these men are well enough off, and have their own houses.) He has also a certain fraction of what the company get for each wagon, *provided* he gets coal out for less than 4 marks (4s) a-ton of 1000 kilos.; if for more than 4 marks he gets nothing. The less the company pays the more he gets. The fraction differs with the company. To become Obersteiger, a man must attend the Bergschule—a technical and industrial school—and pass an examination out of the first-class of the school to get the necessary certificate. The Obersteiger occupies himself *exclusively* below ground. The colliery officials are:—

	Thalers a-Year.
1. Director.	
2. Betriebsführer, ...	1000 to 1500.
3. Obersteiger, ...	800 to 1000.
4. Steiger.	600 to 800.
5. Wettermann.	
6. Fahrhauer.	

The Oberbergamt is a Board appointed by Government, and looks especially after accidents and boiler inspections, as well as inspecting the mines themselves. This Board is composed of the following officials :—1, Oberberghauptman ; 2, Oberbergrath ; 3, Bergrath ; 4, Revierbeamt. The Revierbeamt looks after the Royalty for Government, like the inspectors in Belgium. This Royalty is 2 % of the actual selling price of the coal.

Mr ANDERSON said in the Table III (No. 8), there was the size of a fan given at 32·8, and width, 13ft. 2in., the number of revolutions at 50 per minute, and the quantity of air was $\{^{51,460}_{33,900}\}$ 33,900 was the available quantity—was that for the fan or for the furnace.

Mr J. H. RONALDSON—The number 1 was for the fan, and the other for the furnace.

Mr ANDERSON—It struck him as an exceedingly small quantity of air considering the number of revolutions. As the chairman said, they are a little behind. We could get a far better result here with smaller fans. Whether it was due to the great number of pipes he could not tell, but it was a very small result.

The CHAIRMAN had no doubt it was due to that very cause. Talking of fans—there was a very valuable piece of information in this paper. It was in regard to the two fans, one exhausting from the other. It was the first time he had seen it. He thought it was generally conceded that fans of enormous diameter were a mistake, very apt to break down, and liable to go wrong. By this process of allowing two fans of moderate dimensions to exhaust into one another the advantage was gained—that the one could be depended on in the case of the other breaking down. This arrangement is better than the present one, double the quantity is not got, but a considerable proportion. Two fans of 30 feet diameter would be equal to one of 42 feet in diameter. It would be better to have two of 30 feet than one of 42 feet. This was an admirable idea.

Mr DRINNAN agreed with all the other speakers that it was a most important and valuable paper. The members could not help feeling grateful to Mr Ronaldson for translating it. It brought a great amount of knowledge within their reach. It would be delusive to attempt comparisons between fans from the

information here given. In order to decide on the efficiency of one fan as compared with another, it would be necessary to know the length and size of their several airways.

Mr R. T. MOORE—They had the particulars given in the paper in the equivalent orifice, which was simply a measure of the resistance due to the passage of the air through the mine.

Mr DRINNAN—Would Mr Moore state what was really meant by the equivalent orifice?

Mr MOORE—The size of the hole in square feet was the equivalent orifice. It was equivalent to saying that the mine was such that—with a given water gauge—there was a certain quantity of air going through it.

The CHAIRMAN—There were many things to be taken into account. The expressions were invented to avoid difficulties. Driving the main roads in one seam, and cutting through crosscut mines was the most available way of working such mines. His experience both here and abroad in the working of mines showed that generally circumstances guide people to adopt the best means adapted to the case.

Mr ANDERSON—There was 12·5 as an equivalent orifice. Where was that taken from?

Mr RONALDSON—The fan must for the moment be left out of account. The fan has nothing to do with the idea of equivalent orifice. You must imagine this 12·5 to be the area in square feet of an aperture in a thin plate through which the same quantity of air would pass as was passing in this given mine, when the difference of the pressure on each side of the thin plate was the same as the water guage, given by a fan or furnace or other means of ventilation.

Mr DRINNAN—I understand it was the same as if a hole was bored through a trap door, separating intake and return airways, and a water gauge inserted to determine the difference of pressure.

Mr RONALDSON—It was supposed only that the plate was there—to judge the size of the orifice.

The CHAIRMAN—It was a mathematical definition altogether.

Mr DRINNAN—Could it not be so stated as to help us to determine the matter at issue.

Mr R. T. MOORE—Perhaps the idea might be rendered more

intelligible by supposing that there was a stopping between the intake and the return. Then if a hole 12·5 square feet area were made in this stopping, and the water gauge kept constant, the same quantity of air would pass through it as was passing through the mine. Or, to take an example, if there were 50,000 cubic feet per minute passing through the mine with an inch of water gauge, then the hole through which this water gauge would force 50,000 cubic feet per minute would be the equivalent orifice.

The SECRETARY—If some one would suppose a case—say 50,000 cubic feet per minute and water gauge equal to an inch—and work it out on the black board, the members might see it more clearly, and also be able to calculate for themselves afterwards.

Mr J. H. RONALDSON—The standard is arbitrary and the originator takes a certain standard and he compares all other mines with this standard.

Mr R. T. MOORE—The formula for calculating the equivalent orifice is $a = \frac{\cdot 000385\ Q}{\sqrt{h}}$ where a = equivalent orifice in square feet, Q = quantity of air in cubic feet per minute, h = height of water gauge in inches. Applying this formula, then we have $a = \frac{\cdot 000385 \times 50{,}000}{\sqrt{1}}$ = 19·25 square feet, so that a mine which passes 50,000 cubic feet at an inch of water gauge has an equivalent orifice of 19¼ square feet.

Mr ROBSON thought the "equivalent orifice" of a mine might be checked by experiment in the following way:—Suppose a fan working in the mine, discharging say 50,000 cubic feet per minute, and the water gauge at the fan 1 inch. Now, by cutting off the connection with the shaft by an air-tight partition, fixing a thin partition immediately in front of the inlet to the fan, and allowing the fan to take its air direct from the atmosphere through an opening in this thin partition, then by regulating the size of this opening until the same quantity of air passes at the same water gauge, the sectional area of such opening will be the equivalent orifice. The latter will be found to be proportionately large in mines where the total resistance is small and vice-versa.

Mr DRINNAN thought he now understood the matter. He was disposed to think that if he had read the foot note at 182 he would have understood it sooner, for Mr Ronaldson has expressed

it there in the same way as Mr Robson had done it. It was explained there; and he had to confess that he had not read the paper in its entirety before coming here, and must in that way get out of the blunder.

The CHAIRMAN—You are not singular in this.

Mr M'CALLUM—Supposing you have two pits—one with a natural draught and the other not. Suppose a fan on the natural draught and you will get a result quite different from the fan on the other one. How can you compare these two fans? I have seen a case where, when the fan was stopped and the doors opened the air went bolt down the pit like a bullet.

The CHAIRMAN—The fan was in its wrong place. (Laughter.)

Mr M'CALLUM—It was most useful and in the only place we could put it at the time. How do you go to work to compare them?

Mr DRINNAN—Suppose you have air-ways in each of these pits of equal length, then you would have a much smaller equivalent orifice in that pit where the natural draught goes down. That would be the effect it would have.

Mr M'CALLUM—You would have lost a good deal of air.

Mr DRINNAN—And so the equivalent orifice would be smaller.

The CHAIRMAN—No doubt of it. As some members have to go to the train, I will hold the discussion adjourned.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 16th NOVEMBER, 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Thirty-nine members were present at the meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

The following Gentlemen were balloted for, and admitted as Ordinary Members :—

JAMES COLQUHOUN, Tredegar Iron Works, South Wales.
JAMES WALLACE, Coalmaster, Wester Gartshore Colliery, Kirkintilloch.
JOHN LOVE, Colliery Manager, Portland Iron Works, Hurlford.
WILLIAM CAREY, Grange Colliery, Bo'ness.

Other six gentlemen were then nominated for election, and will be balloted for at the first meeting.

DISCUSSION ON MR ROBSON'S PAPER.

Mr BARROWMAN, on the resumption of the discussion on this paper, said he did not know that sufficient prominence had been given to the fact of coal dust, along with firedamp, being a very powerful element in the way of an explosion. Mr Robson had referred to it, of course, at the close of his paper, but it seemed to him (the speaker) it deserved greater notice than it had got. It seemed that a very small admixture of firedamp would start an explosion if fired, and this, disturbing dust, might spread the

area of the explosion and intensify it to an almost unlimited degree. This showed the very great importance of there being no gas allowed to accumulate in any place, especially in a working which produced coal dust or dust of any other kind.

Mr M'CREATH quite agreed with Mr Robson when he said that numerous small goaves were objectionable; and also as to the formation of large areas of waste. He was glad to say that, while this was formerly in favour, managers were now becoming alive to the advantage of keeping their workings more systematic and concentrating their operations. The improvement in this respect, as far as he had seen, was very much more rapid than at one time expected. On every occasion when the Government Inspector's Reports came out, he was very much grieved to see the low position as regards safety that their district held. If each one of the members of this Institute would set himself with a will to improve the system of working and the discipline he thought they might before long be able to rival the safest district in England. (Hear, hear.)

In the absence of Mr Robson, further remarks on the paper were deferred.

DISCUSSION ON MR RONALDSON'S PAPER.

The PRESIDENT, in reference to this paper, called attention to the letter at page 221, and pointed out that in Germany the mineral belonged to the Government, and the Government Inspectors, in addition to the ordinary duties of looking after the state of mining matters in regard to safety, had also to look after the landlord's interests. In fact, they were a combination of Mr M'Creath and himself, and that accounted for the extra number of them.

Mr DRINNAN, before the discussion was closed wished to call attention again to one thing, viz., the "equivalent orifice." He was sorry to see that Mr Ronaldson and Mr R. T. Moore were not present as he wished specially to address himself to them, to see if they could not give him any further imformation in regard to this subject. A difficulty had occurred to him in connection with it, viz., suppose they had a fan on a mine, and that a certain

"equivalent orifice" was obtained as indicating the resistance of the mine, and that they had a fan in another mine, the "equivalent orifice" of which had been obtained, how could they compare those fans to see which was doing the best work? Was there any means of comparison so as to show which would be the most efficient fan? This was a thing he would like to hear explained, if it were possible to explain it, because, suppose the "equivalent orifice" was smaller in one case than the other, they would not be able to tell whether it was due to the inefficiency of the fan or the greater resistance of the airways; or, supposing the "equivalent orifice" of each had been obtained, the speed of the fans was then increased, and it was found that one fan obtained a greater proportion of air than the other, it would still remain an open question whether this was due to the greater efficiency of the fan, or a lesser resistance in the airways.

The PRESIDENT said the equivalent orifice is useful when comparing the duty of fans, and it assumes that the velocity of the air in the fan drift is the same in both cases—thus:—Supposing two fans of equal capacity, each producing a water-gauge of 1 inch, but the one producing 20,000 cubic feet and the other 10,000 feet, the duty of these fans could not properly be compared with each other unless the area at a point in the fan drift of the one giving the less quantity were so reduced that the velocity of the air passing through it to the fan was the same as that of the larger one, and then it would be found that in order to make the fan deliver a quantity equal to the larger one through this small opening eight times the power would be required. It will thus be seen that fans of equal sizes may give very different results with the same speed of periphery, but perhaps there is no complete test of two fans unless each were placed on the same pit.

Mr DRINNAN had said something of the same kind at last meeting, viz., that he thought it would be delusive to attempt a comparison of fans working on different mines, and it was stated that the "equivalent orifice" indicated that. The idea was a new one, and on thinking over it, he could not really see how the "equivalent orifice" could tell. He was of the same opinion as the President as to the only way in which it could really be done.

Mr M'Grath thought that at a former meeting they had it made out that the "equivalent orifice" just gave them the same information as if they had been told that an inch of water gauge would produce a certain current of air. That was all the information the "equivalent orifice" gave them.

The President then closed the discussion, and moved a vote of thanks to Mr Ronaldson for his paper, which was heartily accorded.

DISCUSSION ON MR RUSSELL'S PAPER.

Mr Russell, in answer to the President, said he had no remarks to make supplemental to his paper except as to the question of cost, and likewise a correction. At p. 202, it was stated the thickness was nearly 5 ft., while it ought to be nearly 6 ft. As to the question of cost, the cost for both methods for prop wood was about the same. The cost of working by the first method was 5d per load, while they lost the "Water-leaf" coal over and above. The cost by the second method was 4¾d per load, and they were able to take out all the coal without any loss whatever.

Mr Ronaldson asked what was the weight of the load, how many cwts. was it supposed to be?

Mr Russell—4½ cwt.

Mr Dixon thought papers of this kind were very instructive, their object being to show where they could apply a system, if successful in one district, in another. He would like to ask Mr Russell what he did with an increase of the bed between the two seams, or if he had any experience with it increasing to 9 feet? As regards the cost, it appeared to amount to this: in the old plan of working they took out all the coal by the same roads forward and back; by the present system two sets of roads were used, one forward and an th back, the latter on the stowage or in the cundies. Now, that would entail double brushing, and of course that must enhance the cost of the coal. He could appreciate the object of this plan, viz., the saving of the "Water-leaf" coal. He had a perfect horror of seeing coal lost, and he certainly appreciated anything

by which that loss of coal could be overcome. He should like an answer to those points, viz., how the working was conducted with a parting so much thicker, and if the new system entailed double brushing, and what was the cost for that?

Mr RUSSELL said when the stone became thick they left it in and worked it out by what they called the "Wee coal." The Turf coal got another name—the name of the Wee coal—and there was no brushing entailed in working it out, because in the first working the stone between the two, all came down and was built, and in the second they did not brush any. They only took off the clay on the top in the Splint, and built their walls with it, so that there was no brushing entailed whatever.

Mr HASTIE said Mr Russell had not mentioned what the props cost per ton. He would like to know that.

Mr RUSSELL could not exactly give that; but in both systems the cost was equal.

Mr DRINNAN said it seemed to him that those roads would be somewhat low. The height of the Splint coal was stated to be somewhere about 3 to 3½ feet, and the stone was 13 inches, or very little over 4 feet for the height of the roads. Those were very low roads, he should think. Of course, by the use of a very low tub it might be possible to get in, but otherwise, he should imagine, it would be altogether insufficient, because he believed the roof would be likely to subside a good deal. He would like also to have a little fuller explanation, if possible, with regard to the ventilation. It seemed to him that it would be a somewhat difficult thing to ventilate that; at least it would require a good deal of attention, sending the air up those old roads and along the faces of the Splint coal as they were being worked. Perhaps Mr Russell could give some information as to how communication was kept up with those faces and the old Turf roads,—if it did not require constant attention in keeping them open in consequence of the advancing faces breaking the roof.

The PRESIDENT asked what was the area worked? Were there 20 acres or 30 acres?

Mr RUSSELL—Not more than 4 or 5 acres. Mr Drinnan spoke of the stone on the top. It was 20 inches.

The PRESIDENT—You have said 13 inches.

Mr RUSSELL—That is in the working of the Turf coal, but on the top of the Splint coal it is 20 inches, and the workings are nearly the height of 5 feet in that seam.

The PRESIDENT—I expect Mr Drinnan means the height in the Turf coal?

Mr DRINNAN—No; it was the Splint, but I have made a mistake. I thought it was 13 inches between the Turf and the Splint.

The PRESIDENT—As I understand the Turf coal is the lowest.

Mr RUSSELL—Yes, and it is worked first.

The PRESIDENT—And separated from the Splint by 13 inches, so that, unless you brush the Splint coal, it will be the height of the Splint coal plus 9 inches of stuff. What height is that?

Mr RUSSELL—Nearly 6 feet. But that was only speaking of the Turf coal; it was not speaking of the Splint at all. Those were first workings.

Mr DRINNAN could not say he understood it yet. His understanding was that this Turf coal being worked out, there would be this 13 inches of stone taken down in some way, but it would appear now that this 13 inches of stone that separated the Turf and Splint was taken down while the Turf was being worked; and there would only remain, it seemed to him, the height of the Splint unless he brushed something above the Splint coal.

Mr BARROWMAN pointed out that at page 203, Mr Russell mentioned how the coal was worked.

The PRESIDENT explained that on the top of the Splint lay a few inches of coal, which in the former working they used to leave, but in the second mode Mr Russell mentioned the holing in the top of the coal, and that gave him stuff for building, and he got the whole coal out.

Mr RUSSELL—That is so.

Mr DRINNAN simply assumed that that was a holing on the top of the Splint coal.

The PRESIDENT said they would observe that it was a bad roof apparently, and he had to leave on a portion of the Water-leaf coal in order to make a roof, but when they took out that soft stuff they had a good roof above.

Mr RUSSELL—That is so. Twenty inches were taken off the top and thrown behind them.

Mr RONALDSON asked, in the previous method of working back the Splint coal, were the faces kept all in a line, or was one considerably in advance of the other?

Mr RUSSELL—The one was considerably in advance of the other coming back.

Mr RONALDSON—Would the ventilation not have been improved if the faces had been kept more in a line, like long-wall?

Mr RUSSELL said they might have been unable to keep up the roof, because they had no pack walls.

Mr RONALDSON—How would it do suppose you were working it backwards, holing in the clay, and throwing the stuff behind, and working it according to the proposed system of back-splinting?

Mr RUSSELL—What I understand from you just now is the working of it back in the same method as I have described the working of it forward?

Mr RONALDSON—Yes; would it not work as well working it backwards and holing in the clay and throwing it back into the waste behind?

Mr RUSSELL—You could not manage stowage for your clay under that system.

Mr JAMIESON did not see any difficulty in Mr Russell's system where the stratum was only 13 or 18 inches, but when it came to 9 feet, how did he work it?

The PRESIDENT—Mr Russell has already explained that,—by two workings.

Mr JAMIESON—Doesn't he take the top seam the same road?

Mr ANDERSON—Mr Russell said that this system was applicable to many parts of Lanarkshire. Is the depth there the same as hereabout, 120 to 150 fathoms? Do you get enough material to stow the waste?

Mr RUSSELL said the depth of the working in question was 70 fathoms fully, and as to the roads being improperly stowed he could tell him if he had to deal with it he would be thinking he had not enough even in the second method, because they had the breadth of the road to keep, and they had good pack walls on each side.

Mr ANDERSON—Do you get that out of the holing?

Mr RUSSELL—Yes, and it stows it well. In fact, they had to draw some of it.

Mr DIXON said this question of working one seam forward below and another back above was of great interest. Had Mr Russell any experience in working this same seam by stoop-and-room, and what would be the advantage of working by two roads as described, compared with stooping? Did the top seam break up very much by being allowed to settle down on the buildings? The usual idea was—and he thought it was the correct one in most cases—that it is desirable to use the roads and buildings of the lower seam for the seam above. By this mode, after working a certain distance they came back, and left the waste behind. In the plan described they created a new waste, and there would be considerable difficulty in keeping the roads open.

Mr RONALDSON—Might I ask what the actual height of the roads is 50 fathoms back from the working face?

Mr RUSSELL—3 ft. to 3 ft. 4 in.

The PRESIDENT said there was no great difficulty in ascertaining the thickness of brushing necessary to make good roads. It was almost certain that the depression due to a long-wall working would be 75 per cent. or 9 in. to the foot of the material taken out. He recollected some years ago having occasion to test that in Govan Colliery, and the way he took was this: he took an Ordnance datum marked on the ground where there had been no subsidence—no coal worked—and he took another point and levelled to an ordnance bench mark in the centre of the depression, and then he saw from the plans the thickness of the coal. He tried that in more than one place, and found in each case the subsidence was 9 in. to the foot of the material worked. Taking those data, the depression of the 3 ft. coal would only be 18 inches, so that the roads would be 18 inches less than 4 ft. 10 in., or 3 ft. 4 in.

Mr RUSSELL said they had found it to be so. He also mentioned that the hutches were very small—not what they found about here.

The PRESIDENT—You should make them larger. As regards the height, there was no doubt about that at all to his mind.

Mr BARROWMAN thought it would be interesting for them to get a short paper from Mr Russell, say a twelvemonth hence,

after he had further experimented on or proved this method. He did not know that the small area that had been proved was quite a good indication of the value of this new method as compared with the former one.

The PRESIDENT might say it was not at all a new method. Mr Jamieson was working the Main coal and Pyotshaw coal at Tannochside in the same fashion, and it was regularly worked in Dunfermline.

Mr JAMIESON might say when the strata was from 3ft. to 5ft. between the coal it made the best work. In some places, it is close together, and we pursue the same course.

Mr DIXON—The difference is you use the same roads going in and coming out.

The PRESIDENT mentioned that in Balgonie, in Fife, they had a coal 15ft. thick, which they worked long-wall. The first working was about 6ft., and then the roads were the usual width, and they cut them off by means of a cross road. Whenever one wall was cut off by a new cross road, they began at the last cross road, taking the coal forward, not back, until they come to the next cross road. In that way, they observed, they got the road always a little higher as they went in. He thought that was an improvement. In that way they could work two or three elevations. At a colliery near Wemyss they worked the Chemiss coal in the same way, working the lower seam first and using the old roads again for the upper. With regard to the system which was here proposed, of making new roads, it did not seem to him that there was any benefit over using the old ones. At the same time, he quite agreed with the remarks Mr Dixon had made as to how useful it was that they should have from practical men the varied systems of working in this way. He thought there was certainly room for improvement at the place in question in respect of the leaving on of the Water-leaf coal for the sake of the 18 inches of "falling," and if there was nothing else, he thought Mr Russell had made an improvement on the working, and instead of 4 acres he (the President) hoped he might extend it to a large district.

Mr PRENTICE, referring to the list of Lanarkshire and Ayrshire coal seams given in the paper, said he quite agreed with the first

four. As to the fifth—the Ladyhall—Mr Russell said it was the corresponding seam to the Humph coal in Lanarkshire. This was a mistake. The Ladyhall coal throughout the whole of Ayrshire was well known to be below the Splint coal. Mr Russell co-related it with the Humph coal. There was a coal in Ayrshire in the Irvine basin which corresponded with the Humph coal, but it was unworkable owing to the defective roof.

Mr RUSSELL said he only got his information from old journals of bores, and he could not speak definitely on the subject.

Mr M'CREATH thought the Ladyhall coal lay below the Splint.

Mr PRENTICE thought after they passed the Turf coal it would be very difficult to co-relate the corresponding seams in Ayrshire with those of Lanarkshire.

Mr RONALDSON said the Ayrshire seams were very confusing owing to the change of names in different localities.

The PRESIDENT supposed it would satisfy everyone to say that Mr Russell admitted that the classification of the coals on p. 202 was not very clearly made out, and might be wrong.

Mr HASTIE said Mr Dixon asked a question which he would like to hear answered. If Mr Russell would just state his experience in the first method as to the amount and area he worked, and the amount or area in the second, and give an opinion which of the two was best, it would meet the case. Mr Barrowman thought he would best answer in a twelvemonth, but this would be best done now.

Mr RUSSELL had worked out the coal long-wall under the first method, and got more than the half of it, as there was the loss of the Water-leaf coal. Then it was almost impossible to keep up the ventilation from the way the walls were coming back, one considerably in advance of the other. Under the second method, there were only four acres. None of it was tried stoop-and-room.

Mr RONALDSON said they used to work the Splint coal, he thought, in No. 9 Annandale Colliery, stoop-and-room.

Mr RUSSELL said it was in No. 10 Pit, some ten years ago.

The SECRETARY, referring to Mr Russell's correction of the statement on p. 202, said in the MS. the thickness was put nearly 6 ft, but altered to be more in keeping with what appeared from the context.

Mr DRINNAN said Mr Russell had not said how he ventilated his new method, and he (Mr Drinnan) still thought there would be considerable difficulty in ventilating it.

Mr RUSSELL said it was just ventilated in the same way as other long-wall workings.

Mr DRINNAN said his idea was the subsidence would have a tendency to squeeze the pack walls so as to close the old Turf roads.

Mr RUSSELL said it was not so in their experience, because after it was worked he could go up the old Turf roads. Of course it was a mere crawl.

The PRESIDENT asked how many thousand feet of air was passed per minute?

Mr RUSSELL—2000 feet. They had no gas.

Mr HASTIE said he made it out the area to which Mr Russell's paper referred was very small and the depth very little, being only about the half what they met with here, and any one making the experiment with 50 acres would require to go on a more extensive scale as regarded the roads for height.

The PRESIDENT said the circumstances were a little different from the generality of the working of this district, but they must remember that they did not propose to speak for this district only. In closing the discussion, he was sure they would agree that Mr Russell deserved a vote of thanks for his paper. (Applause.)

ON THE SUCKING POWER OF THE COMMON PUMP, AND ON SOME OF THE SHOCKS WHICH OCCUR IN PUMPING.

BY JAMES M'CREATH.

The common bucket or ram pumps are so familiar to all present that I shall dispense with any description of them; but common as they are, the study of their working requires some application.

In the innumerable varieties of situations where underground pumping is required a colliery manager may have frequently the question suggested to him:—How far vertically and horizontally can water be sucked at a definite speed by a common bucket or ram pump? The first part of what follows is intended to shew how this can be answered, and the second is intended to be a contribution towards a consideration of the shocks occasioned when a pump is overdriven.

The sucking of water being dependent on the pressure of air, and as air can for all practical purposes be considered a perfect gas, it may be convenient to recall Professor Rankine's definition thereof, viz. :—"A perfect gas is a substance in such a condition that the total pressure exerted by any number of portions of it at a given temperature against the sides of the vessel in which they are enclosed is the sum of the pressure which each portion would exert if enclosed in the vessel separately at the same temperature."

The pressure which the atmosphere exerts at the level of the sea is seldom less, and is never much less, than will support a column of water 32 feet in height, and this height is therefore a convenient standard for reference in regard to pumping. For every 262 feet above sea level the pressure is about $\frac{1}{100}$th of itself less, as stated by Professor Rankine.

If the bottom of a pump open at top be inserted in water the pressure of the air on the surface of the water outside and inside the pump is alike, but if the bucket be put in and made to descend, the air between the bucket and clack is compressed until the bucket valve opens, and at the bottom of the stroke the valve again shuts, when the excess of pressure becomes too little to support its weight although still slightly above that of the atmosphere. On the return stroke, a portion of the atmospheric pressure is taken off the air within the pump, which then itself presses upon the water inside with the like less pressure, but the water outside having the full atmospheric pressure is forced up into the pump until the balance is restored.

The proportion of the height of 32 feet then to which water can be raised in a pump depends upon the proportion of the air within the pump which the pump can extract, and this depends upon its proportions. For example:—A pump the bucket of which at top of

stroke is 20 feet above the level of the water, the length of stroke being 2 feet and clack being 16 feet above the water, can never suck the water up to the clack, because at the bottom of the stroke the air pressure must be slightly more than that of the atmosphere, and at the top of the stroke, the air then occupying double the space, the pressure must be slightly more than half of that, and therefore the water will not rise to quite the half of 32 feet which it would require to do to reach the clack. If the pump be filled with water from the outside it will raise water until air again collects in it.

Dr Robison in his elaborate article on pumps contained in some of the older editions of the *Encyclopædia Britannica* points out that a pump to be reliable must be proportioned, first, so that when put in action it may clear itself of air when wholly or partially filled with it; and secondly, that the water may follow the bucket or ram in the upstroke at the required speed of pumping.

Setting aside for the time the imperfections of the pump and the weight of the valves and slip of water past the clack, he shews that a pump with a uniform size of pipe must have, in order that it may clear itself of air, the height of the bucket at the top of its stroke above the surface of the water in the well so short that the square of its half in feet shall be less than the stroke of the bucket multiplied by the number of feet of water equivalent to the pressure of the atmosphere, provided that the clack be mid way between the bucket at the top of the stroke and the surface of the water in the well or lower. If the clack be higher than this the height of the clack above the water in the well must be less than the length of stroke multiplied by the head of water equivalent to atmospheric pressure, and divided by the distance between the clack and bucket at the top of its stroke. An allowance must be deducted from the length of stroke for the effect of the weight of the bucket valve and from the column of water to be raised for the weight of the clack valve and the slip of water past it. The following are examples of what the utmost rarefaction of air producible by various lengths of stroke and distances between bucket and clack can do; 32 feet of water being taken as equivalent to the atmospheric pressure.

With the Low Clack.

Length of Stroke in Feet.				Greatest Height of Bucket at Top of Stroke above Water in Well which will admit of Water being Raised.
1 × 32	= 32,	- -	- 2 $\sqrt{32}$	= 11·3 feet.
2 × 32	= 64,	- -	- 2 $\sqrt{64}$	= 16 feet.

With the High Clack.

Length of Stroke in Feet.	Distance between Bucket and Clack Valves at Bottom of Stroke.	Height Water will Rise to Clack.
1 - - -	1 - - -	$\frac{1}{2} \times 32 = 16$
2 - - -	1 - - -	$\frac{2}{3} \times 32 = 21\frac{1}{3}$

This raises the water only to the clack. Very little of a longer stroke would raise it to the bucket, for the air space to be exhausted lessens as the water rises above the clack, but some allowance must, as before mentioned, also be made for the water returning through the valve while it is closing, provided a sufficient pause at end of stroke be not made to let it fall. If the water get above the bucket, either by suction or by being filled from the outside, and the bucket be steadily raised the water will in time follow the bucket until it reaches 32 feet above the water in the well, but if it does not reach the bucket of course no water will be pumped.

If the clack piece be wider than the working barrel it must, for the calculation of the rarefaction, be taken longer in proportion.

The height to which water will rise in a ram pump may be calculated in the same way, the space under and around the ram being reduced to an equivalent length of pipe of the diameter of the ram between the bucket and clack. Provision ought to be made for the escape of air remaining around the ram above the level of the exit pipe.

It will thus be seen that the capacity of an ordinary pump to clear itself of air depends directly upon the length of the stroke, and, within certain limits, inversely as the distance between the bucket and clack.

In determining whether water will follow the bucket at the required speed, Dr. Robison points out that allowance must be made for part of the effect of the atmospheric pressure being used up by contractions and bends of water way, by the obstruction of the clack valve, and by the friction of the water in the pipe.

The effect of the remaining pressure on the column of water to be moved where required is by him assumed to be the same as that of gravity on a column of water corresponding to the pressure; but this would appear to be an overlook, and I would submit that the effect can be the same only when the column of water to be moved is equal to that corresponding to the pressure, and that the resultant speed of flow will be greater than that due to gravity in the proportion that the column acted on is greater than that equivalent to the pressure: for example:—If the available pressure for moving the water be equal to a head of 10 feet of water, and the column to be moved be 100 feet in length, then the acceleration of velocity will be $\frac{10}{100}$ of 32·2 feet per second.

Dr. Julius Weisbach gives the following rules obtained by experiment for the loss of energy of flowing water:—

First.—When flowing through short tubes whose diameter is equal to their length, the water is contracted to 0·61 of the area of the tube.

Second.—When passing round an elbow at right angles 0·984 of (or very nearly the whole) head corresponding to the velocity, is lost.

Third.—When passing round a circular bend, whose radius of curvature is to the radius of the cross section of the pipe as 10 is to 4, the loss of head is equal to about $\frac{1}{8}$th of that corresponding to the velocity.

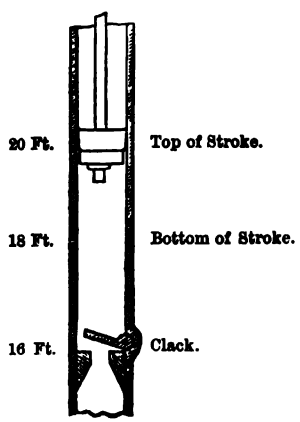


FIG. 1.

Fourth.—When passing through a valve similar to that shewn on Fig. 1, where the cross section of the aperture to that of the pipe is 0·535, the co-efficients of resistance are as follows:—

Angle of Opening,	15°,	20°,	25°,	30°,	35°,	40°,	45°,	50°,	55°,	60°,	65°,	70°.
Co-efficients of Resistance,	90,	62,	42,	30,	20,	14,	9·5,	6·6,	4·6,	3·2,	2·3,	1·7.

Let the foregoing rules be applied to a bucket pump having bends under the clack, as shown on Fig. 2, the length of pipe

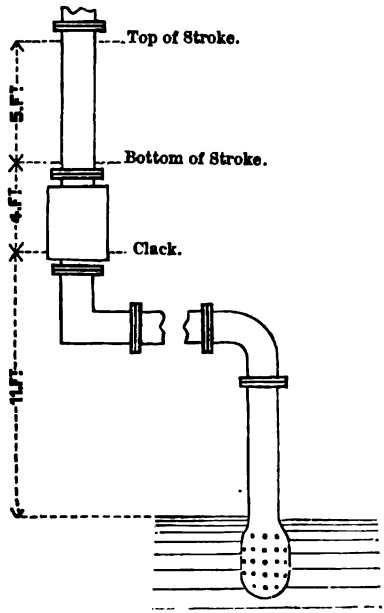


FIG. 2.

from the bottom of the suction pipe to the bucket at half stroke = 100 feet, the height of the bucket at the top of the stroke above the surface of the water in the well = 20 feet, and above the clack at the bottom of the stroke = 4 feet, the stroke = 5 feet, and speed required, 12 strokes a minute, the pump being driven by a crank whose rotating motion is uniform.

In order to find whether the pump can clear itself of air, assume that the weight of the bucket valve be such as to reduce the effective stroke for air to $4\frac{3}{4}$ feet, and the weight of the clack valve and the slip of water past the valve to take 6 inches from the column of water capable of being raised. The length of stroke $4\frac{3}{4}$ feet divided by 9 feet, the distance between the clack and bucket at top of stroke, gives extraction of—$\frac{4\frac{3}{4}}{9} \times 32 = 17$ feet;

and deducting 6 inches for weight of clack valve, and for slip, leaves 16 feet 6 inches which the water would rise to the clack. But the bucket at bottom of stroke is only 15 feet above the water in the well, and there is, therefore, a large margin to cover imperfections in the pump.

In order to ascertain whether the water will follow the bucket at its speed, let the resistances be first ascertained and then the time required to fill the working barrel with the remaining pressure.

The mean velocity of pump assumed is two feet a second, and the resistances at this velocity are—

		Loss of Head in Feet.
Snoreholes and turn into pipe when sum of area of snoreholes = area of section of pipe,	$\frac{\left(2 \times \frac{100}{61}\right)^2}{64{\cdot}4}$	= 0·167
Circular bend, ...	$\frac{2^2}{64{\cdot}4} \times \frac{1}{5}$	= 0·012
Square elbow, ...	$\frac{2^2}{64{\cdot}4}$	= 0·062
Valve at 20°, ...	$\frac{2^2}{64{\cdot}4} \times 62$	= 3·857
Friction of the water in the pipes, say, of twelve inches diameter,		= 0·165
Total resistance due to square of mean velocity,		4·263

But Dr. Weisbach shows that the resistance is as the mean square of velocity, and that in a uniformly accelerated or uniformly retarded motion this is twice the square of the mean velocity, and in a crank motion 1·645 times the square of the mean velocity. Assume, meantime, that the water follows the bucket, the total resistance will be equivalent to 4·2635 × 1·645, equivalent to a head of about 7 feet. The bucket at bottom of stroke, being 15 feet above the water in the well, the pressure at first for raising the water and overcoming resistances is equivalent to 17 feet; but deducting 7 feet for resistances, the pressure available for giving motion to the water will be only 10 feet.

Taking the following approximate formula for time of filling

the working barrel (with the acceleration modified), suitable where extremes of acceleration do not vary greatly, we have

$$\text{Time, } = \frac{2\sqrt{\text{height}}}{\sqrt{\text{twice mean acceleration}}} = 2\sqrt{\frac{5}{64{\cdot}4 \times \frac{10-2{\cdot}5}{100}}} = 2{\cdot}034 \text{ sec.}$$

But the time the bucket takes to make the half stroke is 2½ seconds, so that there is nearly half a second to cover the imperfections of the pump and any hindrance there may be at the beginning of the stroke from the interference of the bucket with the motion of the water.

If an attempt be made to drive the pump at 17 strokes the water will lag behind the bucket and they will meet on the return stroke, the water moving with a velocity of about 4·80 feet per second and the bucket with a velocity of about 1·66 feet per second, together about 6·46 feet per second.

If the water were so far behind the bucket as to meet it at half stroke, a much more serious shock would arise, because in addition to the momentum of the water, the momentum of machinery at a higher velocity, backed by the steam pressure, would have to be met.

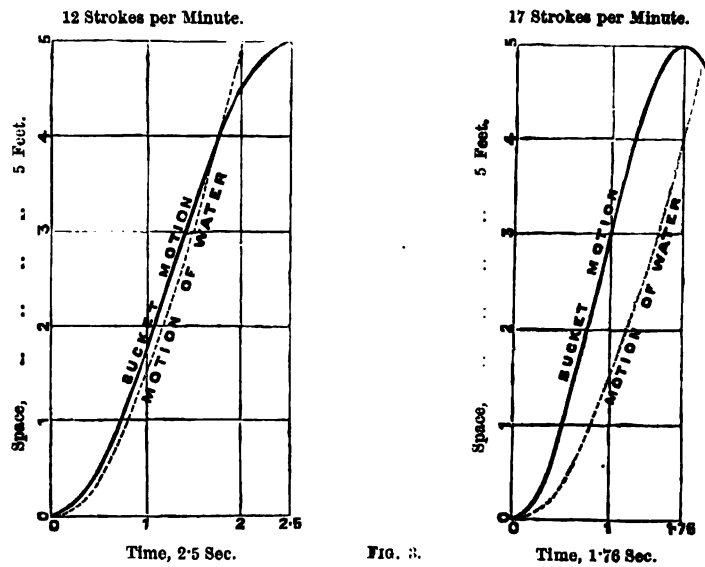


FIG. 3.

The diagram—Fig. 3—will shew the relative motions of the

bucket and the water, supposing the average resistance to be uniform. The speed of the water would, however, if unretarded, be actually greater at the beginning of the stroke and it will be less at the middle of the stroke; the top will therefore be reached a little later than shown.

The foregoing calculations shew that the largest resistance is due to the clack valve, and therefore special attention requires to be given to find a valve giving little resistance when either the height or distance which the water has to be sucked is such as to raise a doubt of the pump working well.

What would be still more effective would be to double the area of the pump and drive at half the speed, and so reduce both the resistances and the work lost in the motion of the water to a fourth. With the pump already instanced the same quantity of water could be sucked 340 feet as freely with a 17 inch bucket and pipes going six strokes a minute as could be done 100 feet with a twelve inch bucket and pipes going 12 strokes a minute; and if in addition the stroke could be lengthened downwards 4 feet, retaining the same velocity, the water could be as easily drawn 390 feet.

The only reference to the calculation of pressure caused by a shock in pumps, which I have observed, is contained in a paper by Mr E. Bainbridge in Volume XXI. of the proceedings of the North of England Institute of Engineers, where he states that having satisfied himself that a bucket piece was broken by the water being suddenly stopped when descending with a velocity of 5ft. a second, he wrote the late Professor Rankine on the subject, who, in his reply, stated that "the total theoretical pressure due to the shock of the column when checked in a velocity of 5ft. per second is 595lbs. on the square inch, but the actual pressure will be less than the theoretical owing to friction and other causes." Mr Bainbridge himself calculated from the thickness of the iron torn asunder that a pressure of about 572lbs. had been exerted.

Unfortunately we have not the process by which Professor Rankine made the calculation, but substantially the same result may be obtained in answer to the question put to him in the following manner, viz. :—Calculate the amount of work in com-

pressing the water and extending the pipe, which would be equivalent to the work due to the fall of the water, keeping in view that a load suddenly applied to an elastic substance will produce double the strain that the same load would do if applied gradually.

I have here a spring balance and a half-pound weight. If I put the weight suddenly in the balance it drops down until the index shows nearly one pound of pressure, and then rebounds, and, as it oscillates alternately above and below the position of half-a-pound of steady load, gives a very good illustration of what is called a "live load."

The height of the column of water above referred to was 339 feet; diameter of pipe, 26 inches; thickness of pipe, $1\frac{3}{4}$ inches. We may take the compressibility of water at $\frac{1}{294,000}$ of itself for each pound of steady load; extensibility of iron, $\frac{1}{17,000,000}$ of itself for each pound of steady load; weight of water, ·433lb. for column, 1 foot in height, 1 inch square, and pressure of column of 339 feet, 147lbs. per square inch.

Let it be assumed first that the work due to the fall has to be met wholly by the compression of the water, then

$$\left.\begin{array}{l}\text{The work due to velocity of 5 feet.}\\ \frac{V^2}{2g} \times \text{Weight of 1ft. of water}\end{array}\right\} = \text{Half of ultimate pressure.} \times \text{Amount of compression.}$$

$$\frac{25}{64{\cdot}4} \times {\cdot}433 = \frac{x}{2} \times \frac{x}{294,000}$$

$$x = 314\text{lbs. per square inch.}$$

This is the ultimate pressure required to meet the momentum of the water if moving horizontally, but the column in question being vertical, it has upon contact the additional compressing force due to a sudden application of a load of 147lbs. viz., double the weight applied = ... 294 lbs.
Add pressure due to stopping 5ft. velocity, . . . 314 lbs.
Total pressure if work met only by water, . . . 608 lbs.

The work, however, is partially met by the stretching of the iron pipe and the proportions borne by each are :—

Work on Water. Work on Iron.

$$26'' \times 26'' \times \frac{3{\cdot}1416}{4} \times \frac{1}{394{,}000} : 26'' \times 3{\cdot}1416 \times \frac{26}{34} \times \frac{1}{17{,}000{,}000} :: {\cdot}00085 : {\cdot}0000168;$$

and 8668 : 608 :: 168 : 12. The total actual theoretical pressure is therefore 608 − 12 = 596 lbs. per square inch.

		Proportion borne by Iron.	
	Lbs.	Lbs.	Lbs.
We have thus, required to stop velocity of 5ft.	314	− 6	= 308
And double the weight of column, . . .	294	− 6	= 288
Total pressure due to fall, ...			596

This is the simplest form of shock. When a bucket or ram is suddenly stopped in descending, the calculation becomes more complicated from the working barrel being partly occupied by iron or wood which are respectively 60 and 6 times less compressible than water, and from the momentum of the machinery backed by the steam pressure having also to be met. The calculation, however, of this simple shock makes more intelligible the thickness of iron practically found necessary in pumps, keeping in view also that repeated shocks weaken cast-iron by a half. It likewise shews that the pressure due to the shock depends upon the velocity of the water when suddenly stopped and the resistance to compression of itself and the resistance to extension of the vessel containing it, and as in an ordinary pressure guage the velocity of the water and the resistance to extension of the vessel containing it are both less than in the working barrel, the pressure indicated must also be less.

Air vessels are found useful in lessening shocks in pumps; but it would appear that within the working barrel they cannot do so to the extent generally supposed. The time taken to compress the water sufficiently to stop a 5-feet velocity and raise 314 lbs. pressure is only $\frac{1}{3000}$th of a second. This time must elapse before the water below the air vessel can begin to flow back, and the extent to which the water above the air vessel can be relieved of the shock due to its velocity must depend on the quantity of water in the air vessel and the direction and rate of its motion at the instant as well as the quantity of air, because the quicker the change of motion and the larger the mass of water, the greater the force required, and an abrupt change of motion requires an infinite force. If there be one foot in length of water between

the main column and the vessel, and that at rest at the beginning of the shock, it will attain the same velocity as the descending water when ·866 of the full compression due to the shock has been reached ; and the pressure will probably not much exceed this proportion thereafter at or above the entrance to the vessel, provided there be sufficient air above the water. About 1½ feet of air would suffice for a shock capable of producing a pressure of 600 lbs. per square inch. No substantial relief would be given if 2 feet of water intervenes between the main column and the air in the vessel. Water may be much more readily driven in or out of the air vessel to or from the bucket than can the whole column of water be moved, because the mass of water to be moved by the same pressure is much less and probably the air vessel is as useful in driving the water downwards to fill a vacancy and so preventing the fall of the column above as in forming a cushion for the fall.

This theory is strengthened by taking a glass tube with a glass air vessel, and a cock at the bottom. Fill the tube with water and observe the surface of the water in the air vessel while the cock is opened. The water in the air vessel will suddenly drop, then rise and then descend steadily as the water in the tube falls. No such sudden drop can be observed at the top of the water in the main tube.

A full treatment, however, of the subject of shocks and air vessels and relief clacks would include the consideration of the power required for pumping, and this the time at our disposal will not permit.

DESCRIPTION OF A SELF-TIPPING CAGE AND GUN-BOAT.

BY THE PRESIDENT.

In a few notes which I made as to my late visit to America, I mentioned having seen in the mines in the Shenandoah district a self-acting tipping cage, and a self-tipping gunboat, or monitor. Through the kindness of Mr Mauchline, the State Inspector there, I got sketches of these, and have got drawings prepared of them. I shall now proceed to describe them :

SELF-TIPPING CAGE.

This cage, which empties itself, and so dispenses with runners, is in use in the mines in the Shenandoah coal-field. The rope, instead of being fastened to the cage itself, is fastened to a frame which envelopes it. The vertical sides of this frame (AA) are channel irons, and run in the slides so as to form guides. The lowest side (B) is a round iron bar. The cage rests upon this by means of two brackets (CC) which keep the bottom two feet above it. The cage is of the ordinary triangular shape, but as it is fastened to the bottom bar, it only requires guides at the top. These guides (DD) only catch one half the depth of the slide. Attached to each of these guides is a small wheel (E), and when the cage arrives at the surface these enter curved lines of rail. (FF), and as the frame continues to ascend, the cage follows the lines of rails, and is tilted up until the bottom becomes vertical, and the coals run out into the shoot. The guides (DD) get out of the slides by means of cuts (HH) made for the purpose. When it is lowered the cage falls back into the slide, and into its original position. It will be seen that the end of the hutch is not vertical, but is sloped at an angle steep enough to make the coals run down when it is tilted up on end. The hutch is not kept on the cage in the way that is usual in this district, but there are holes in the bottom of the cage through which the wheels sink, and the trams rest on the cage.

THE GUNBOAT.

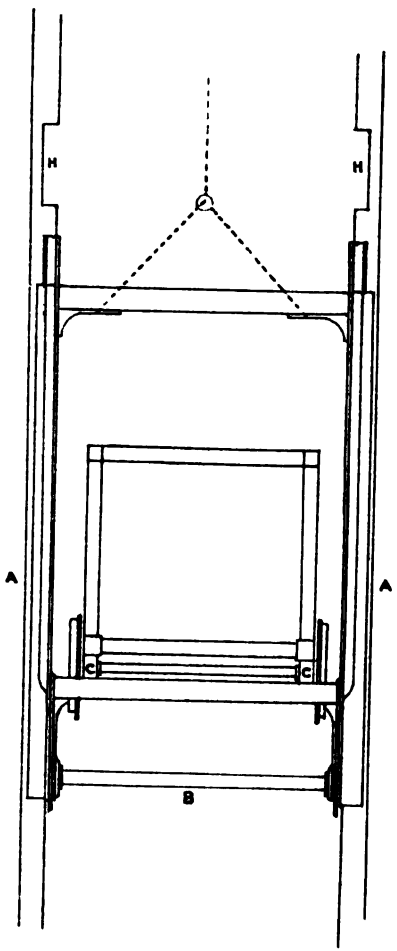
Another very simple application of the same principle is the gunboat, which is used for drawing coals up inclines. It is generally built of boiler iron with angle iron frames, and solid wheels, railroad car pattern, 2ft. in diameter. It is 14ft. long, 7½ft. high, and the gauge is 6ft. The sketch shews one made of wood, lined with iron inside, and used on a steep incline at an angle of 60 degrees. It is covered on the top, but is open at the end, which is made so as to be level when the gunboat is on the incline. When the incline is flat the gunboat is made in the usual waggon shape. Attached to the back end of the gunboat is an axle carrying a pair of small wheels set at a wider gauge, the use of which in the tipping arrangement will he explained further on.

The attachment of the rope is by means of a yoke attached to each side of this axle, and not at the front as is usual in our arrangement. When the gunboat goes to the bottom it runs into a sump, and the hutches are emptied into it in the same way as they were emptied into corves before the days of cages in Scotland. On leaving the bottom it comes up to the surface in the usual way. At a point nearly high enough for emptying the boat a length of rails is fastened on the woodwork at such a height that the small wheels at the back end of the boat will run upon them. At the same point the rails of the incline are curved as shewn in the sketch. The result is that as the rope draws up the back of the gunboat, the front follows the line of rails until it assumes the position shewn in sketch, and the coals drop into the screen or waggon. In some cases the tipping wheels are placed on the hind wheel axle of the gunboat outside the big wheel, which requires 4 inches more space at each side clear of timber, but works equally well. The little wheel is slipped on with a washer between it and the other.

AMERICAN SELF DUMPING CAGE.

Referred to in Mr. MOORE'S Paper.

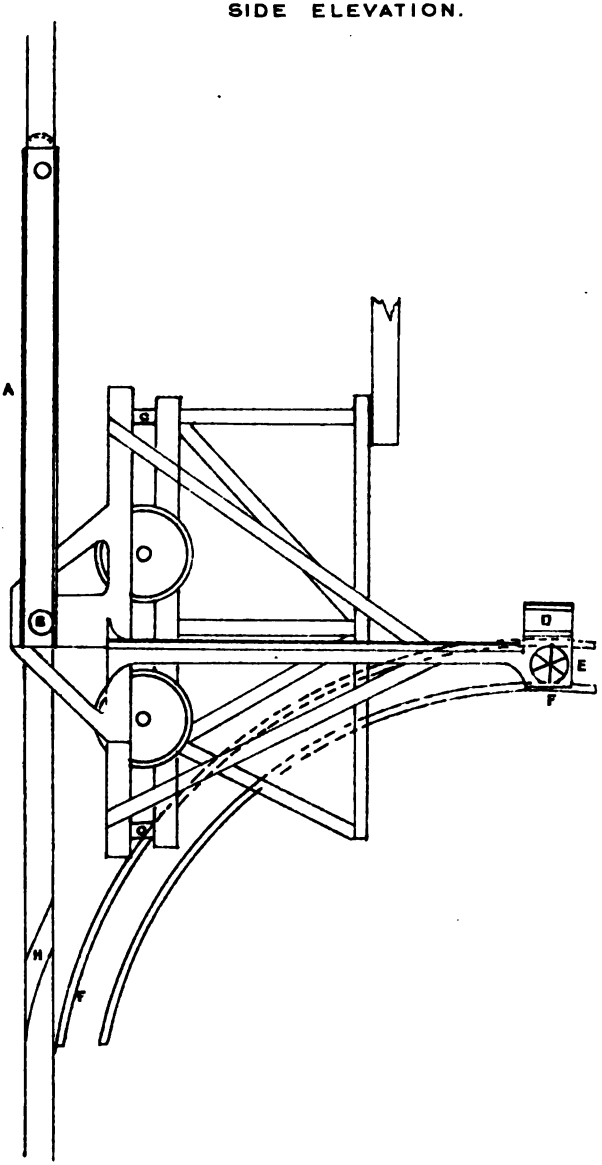
END ELEVATION.



American Self Dumping Cage

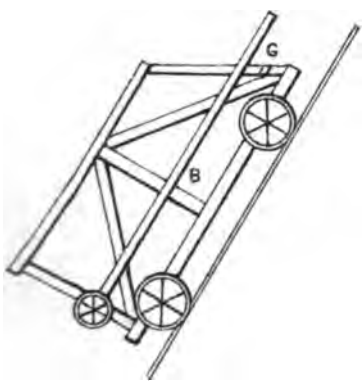
Referred to in Mr. Moore's Paper.

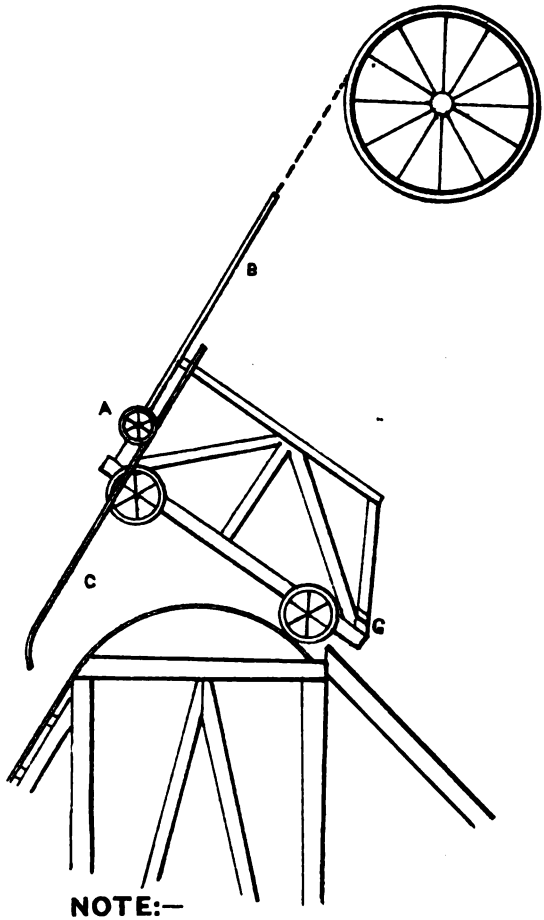
SIDE ELEVATION.



American Self Dumping "Gunboat"

Referred to in Mr Moore's Paper.





NOTE:—

A Common size is: Length 14 ft., gauge 6 ft. diameter of wheels 2 ft., height off the rail 7 ft.

Generally built of boiler-iron with angle iron frame and solid wheels, of railroad pattern. When built of wood the gunboat is lined inside with sheet iron.

A Wheels for tipping.

B Bar iron spreader, jointed on axle of tipping wheels.

C Rail spiked on top gear to catch tipping wheels. While the tipping wheels run up the rail, the front wheels run over the curve, and the coals fall out of the mouth of the gunboat.

G Catch on side of gunboat to keep the spreader from falling down on track when the rope slacks. The tipping wheels are sometimes placed on the hind wheel axle of the gunboat out side the big wheel. In this case 4 inches more space clear of timber is required on each side, but it works equally well

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 14th DECEMBER, 1882,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Owing to the severe weather, only twenty-four members were present.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members :—

D. A. W. ROBERTSON, Mining Engineer, Glenbank, Lenzie.
C. M. PERCY, Mining Engineer, King Street, Wigan.
J. D. M'LAUCHLAN, Mining Engineer, 142 Princes Street, Edinburgh.
JAMES WALDIE, Coalmaster, Tranent Collieries, Tranent.
H. M. GILCHRIST, Coalmaster, Rapid City, Rock Island County, Illinois, U.S.A.
JOHN MORTON, Overman, Knightswood Mines, Maryhill.

Other two gentlemen were then nominated for election, and will be balloted for at the first meeting.

DISCUSSION ON MR McCREATH'S PAPER

On the Sucking Power of the Common Pump, and on Some of the Shocks that Occur in Pumping.

Mr McCreath, before the discussion on his paper proceeded, pointed out the following errors:—P. 243, seventh line, for the word "greater" read "less;" p. 247, fifteenth line, for "340 ft." read "680 ft.;" and on the twentieth line, for "390 ft." read "1415 ft."

The President—This very excellent paper treats, in the first place, of the suction in a common pump, and shews how we may find the best position of the bucket and the clack from the water, and the benefits to be derived from a long stroke and from a slow speed of water in the pumps. The writer shews us in the first example that if a pump is placed so that the water is 16 ft. from the clack, and the bucket 2 ft. from the clack at the bottom of the stroke, which is 2 ft., it is impossible for it to lift water, because the vacuum formed at each stroke between the bottom of the bucket and the clack is only half an atmosphere, or 16 ft. The remedy in such a case is simply to place the bucket so close to the clack that the vacuum formed each stroke will be in excess of what is wanted to raise the water to the bottom of the bucket. In fact, the bucket should always be as close as possible to the clack. In plunger or forcing sets it is seldom necessary to have any suction at all. I think, in all cases where it is possible, the water should enter above the level of the stuffing box.

The next part shews the benefit of the water travelling slowly in the suction end; that the suction pipes should always be larger than the working barrel.

I may remark that with long tail-pipes there is a great advantage in having a vacuum vessel as near the clack as possible, and in having another clack as near the bottom of the suction as possible. It will be readily seen how this vacuum vessel acts. (Fig. 1.) When the bucket ascends the supply is drawn partly from the vacuum vessel and partly from the suction, but whenever the upstroke is finished and the clack shut the vacuum vessel continues to draw water from the suction until it is filled. In this way the resistance may be very much lessened.

In short, by having wide suction pipes and a vacuum vessel as

above, the resistances may be reduced to the weight of the clacks.

The writer then refers to the calculation of the pressure caused by a shock in the pumps, shewing still further the benefits to be derived from slow motions of the water in the rising columns.

He further speaks of the utility of air-vessels, which, in his opinion, do not diminish the strain in the metal of the working

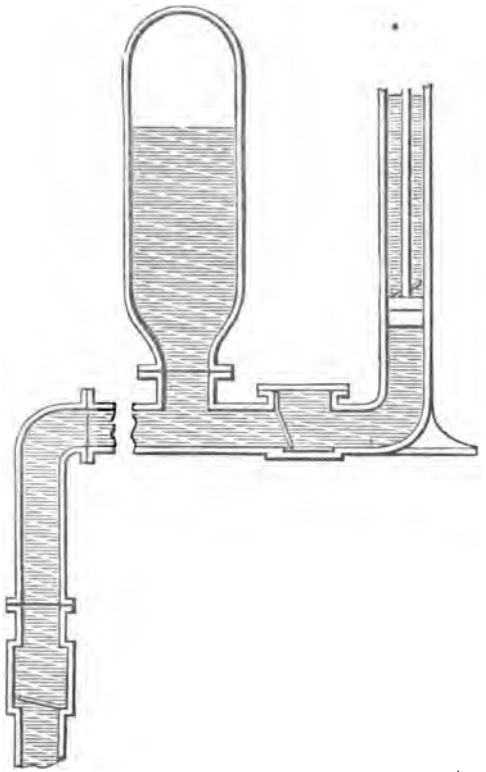


FIG. 1.—Vacuum Vessel for maintaining steady flow in suction.

barrel, although they may assist in sending water more quickly to the bottom of the bucket, and filling up the vacancy between the bottom of the bucket and the water, should there be any. I am not quite inclined to agree with this view. There are many points requiring investigation in this matter, and I hope the writer will go into them.

The whole paper bears out what has always appeared to me to be a proper mode of dealing with pumping: that is to have the pipes of larger diameters than the working barrels or plungers, so that the speed of the water may be less than that of the bucket. There was no doubt that by capacious air vessels they would diminish the shock very much. His brother, Mr Joseph Moore, who was with him that night, mentioned that in the course of his practice in America he had, by using capacious air vessels, pumped water through 18,000 feet of 22-inch pipe, where the engines were working ten 6ft. strokes per minute.

Mr Joseph Moore said that in a water-work which his firm had erected near San Francisco, there were two engines with double-acting plungers 20 inches in diameter. They made ten strokes per minute, and discharged the water through 18,000 feet of 22-inch pipe. The vertical ascent was 370 feet, and the quantity of water raised was over 5,500,000 gallons daily. They had very large air-chambers and valves. The shock was only 5 lbs. to the sq. inch.

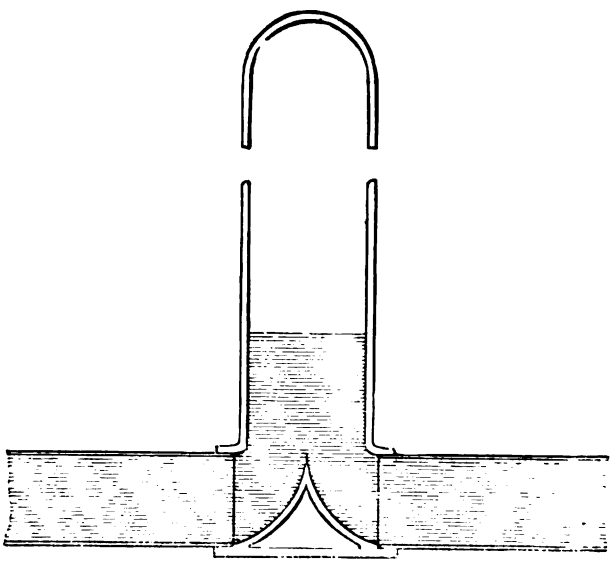


Fig. 2.—Air vessel curved to discharge water against column of air.

Mr Moore showed on the black board how they pumped

through the air-chamber, and said that in some instances the bottom of the air vessel was curved, as shewn in Fig. 2, so that the water was discharged up against the air in the vessel.

Mr M'CREATH asked how much the water might rise where the variation was 250 ?

Mr J. MOORE thought some 18 inches, although he forgot just now, there was one air vessel immediately at the pumps 30ft high and 30 inches diameter. The air was kept down to within three or four feet, and they could do nothing without the air in them. In another arrangement erected by his firm, the vertical column of water was 2500 ft. at a pressure of 1000 lbs. (which made 2000 lbs. per square inch at the bottom) to work two hydraulic engines. The water works company wanted him to guarantee that the vibration should not be over 15lbs. He was a little afraid and would not. He had told them it would not be more than 10, and they got it down to 2½. Without any air vessel, it would have been a failure. To give them an idea of the lightness of the shock, they had 370 feet of head, and the pipe was only a quarter of an inch thick and 22 inches in diameter. They also sucked through 250 feet of a 22 inch pipe. They had two very heavy vacuum chambers, without which they could not have worked, as the ram would have knocked very severely.

The PRESIDENT—Is not that rather against your theory, Mr M'Creath ?

Mr M'CREATH—Oh, no ! There could be very little shock, if there was not much water between the column of water in the pipes and the air, but I should think if there was any considerable quantity of water left there, that it would be impossible to move this water so quickly as to prevent the shock.

Mr J. MOORE said he had noticed the benefit of a vacuum chamber very frequently, and it was especially shewn in fire engines. Indeed, without a vacuum chamber it was almost impossible to keep the suction in the water. But with a vacuum chamber the disturbance was very slight as the water was constantly running in.

Mr M'CREATH—Have you any idea how high the water rose in the air vessel ?

Mr J. MOORE—We kept it as low as we could. All we could do was to see that the force would not throw air into the pipe. I

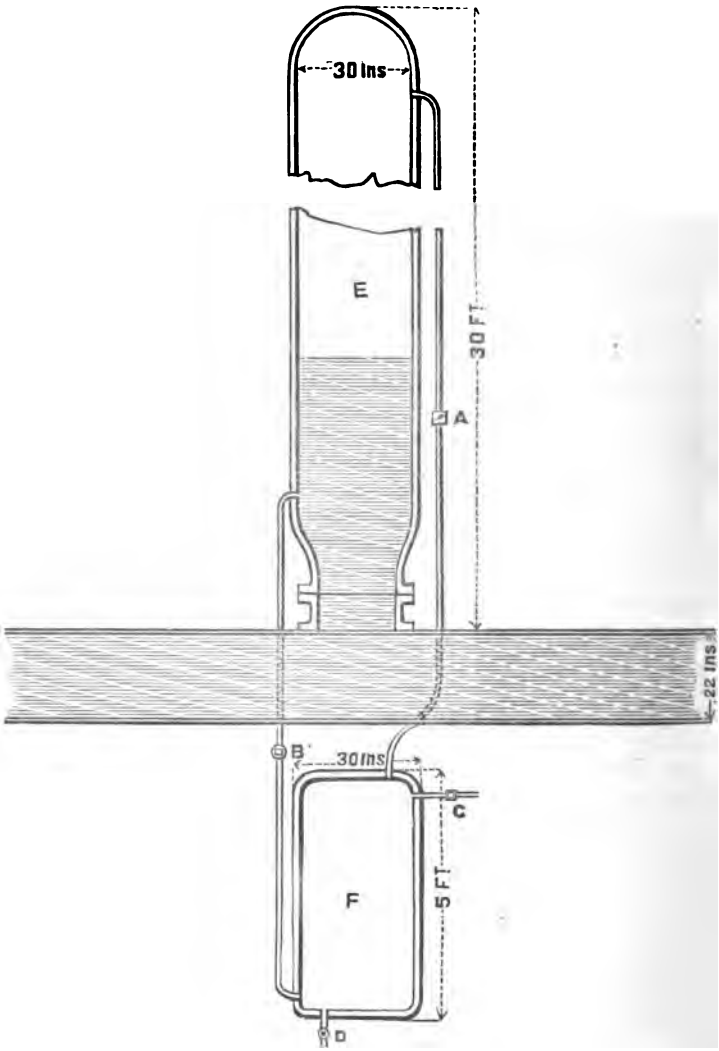


FIG. 8.—Arrangement for charging Air Vessel.

designed an arrangement for charging the chamber with air, which

I have roughly sketched out—E is the air vessel and F is an air-tight cylinder placed underneath it. (Fig. 3). They are connected by means of small malleable iron pipes. One (A) with a valve opening upward reaches from the upper end of the air vessel to the top of the cylinder F. Another (B) with a cock on it connects the lower part of the air vessel with the lower part of F. C is a pipe from the upper end of the cylinder F with a valve opening inwards on it. D is a small pipe with a cock on it from the bottom of the vessel to the atmosphere. When the air chamber is about to be re-charged, the cock on the pipe B being shut there is no communication between E and F as the valve A only opens upward. The cock D is opened to the atmosphere to insure F being full of air. The cock D is now shut and B opened. The result of this is that water runs from the lower part of the air vessel E and fills F, the air from which escapes through A into the upper part of the air vessel. When F is full of water the cock B is shut, D opened and the water runs out, air getting in by the valve C. The operation is repeated until the vessel is charged.

Mr ANDERSON—Does this arrangement work itself?

Mr J. MOORE—It is opened by a man who sets it and goes away.

Mr ANDERSON—With your experience of this vertical column of pipe, you have found it an advantage to have two or three air vessels in the rising column as well as the one at the suction?

Mr J. MOORE—I think so. It gives an elasticity to the whole length of the column.

Mr ANDERSON did not know if any gentleman had used an air vessel in this way. It was new to him.

Mr J. MOORE did not think it necessary for a Cornish lifting pump where the distance was so little. He had just started another pump, a diagram of which he chalked on the black board. He had run that pump 12 strokes a minute,—that was, a 14-inch pump and 5-feet stroke. He had no doubt he could do more, and it was absolutely noiseless. They could not tell it was running.

Mr JOHNSTONE asked whether the same means were used for charging the air vessel attached to this lift?

Mr J. MOORE—The air vessel was charged from the suction.

The pump was almost constantly drawing air, as it was large for its work. That pump lifted 600 ft. They had lifted only 400 ft. yet, but it was made to lift 600 ft. at one lift, and he would not hesitate a moment to put up a pump of the same class for 1200 ft. He had one 5-inch and 6-feet stroke and an air vessel the same.

Mr JOHNSTONE—I have a 5 in. ram working with a stroke of about 10 feet, forcing water through 3 in. pipes, under a head of 87 fathoms. It has an air vessel exactly similar to the sketch, but much smaller—9 ft. long by 11 in. in diameter—and I find it has little or no effect upon the column. The pump referred to cannot draw air, except what it gets through the packing, as the growth of water is largely in excess of what it can lift.

Mr DRINNAN would like to make sure if he had thoroughly grasped Mr Joseph Moore's explanation in regard to the charging of that air vessel. As he understood, the increase of pressure gained after every operation described would be equal to the height of water, and every time the operation was repeated that would be the increase of pressure that would be gained.

The PRESIDENT said the object of this was simply to charge the air vessel with air because they knew water absorbed air, and unless charged now and again, they would lose the benefit of the air vessel altogether. It would be full of water, but this was a ready means of charging the vessel with air.

Mr DRINNAN—So I understand it, but what I wanted to know was, what increase of pressure you would gain by every operation such as described?

The PRESIDENT—You get no increase of pressure—you lose.

Mr DRINNAN—I mean when charging the air vessels.

The PRESIDENT—Charging the air vessels is simply a means of collecting air in the chamber and sending it through the pipe A to the upper portion of the air vessel E. There was no power gained.

Mr J. MOORE said they had never put on air vessels on pumps of the common Cornish style. The air chambers he spoke of were on hydraulic engines in connection with water-works, where they had used them with excessive heads.

Mr M'CREATH—Do you mean this is a vacuum chamber?

Mr J. MOORE—An air vessel.

The PRESIDENT said a vacuum chamber was very easily explained. The first place he saw it was at Glasgow Water Works, under the late Mr M'Kane, who was very great on vacuum vessels.

Mr JOHNSTONE asked Mr M'Creath if he had made any investigation on the subject of the co-efficients of resistance as given at p. 243.

Mr M'CREATH said he had made no experiments. He quoted this because it was the only satisfactory account of the resistance of clacks he could find. It was just as Weisbach gave it.

Mr JOHNSTONE—Did he give any details showing how he arrived at these results? Or did these co-efficients include the loss due to the weight of the clack?

Mr M'CREATH—No. Weisbach merely gives the results of experiments with a valve similar to that shown on a figure which he had just copied.

The PRESIDENT remarked that there must be data for the friction of water in passing through pipes. Many of them had siphons working and could tell the amount of water thrown by them. The resistance of clacks might be obviated very much by having a very large space round the clack, so that it did not open very much, and having the clacks of large area he fancied that very many of these resistances could be lessened.

Mr M'CREATH said in some of the older collieries the clacks were even less than that shewn in the woodcut, but it showed the disadvantage of having one of those clacks, and the advantage of having a roomy clack to allow the water to pass through.

Mr J. MOORE said they never made their clacks less than the diameter of the pipes, and very often larger.

Mr JOHNSTONE said his attention had been specially drawn to the resistance of the clack, by the table given on page 245, from which it appeared that nearly the whole loss of head was due to this resistance. He thought the commonly-accepted notion was that the loss of head caused by a clack, apart from its

weight, was due to the friction arising from the increased velocity of the water in passing through the contracted space, and to the deflection of the current by the clack lid. The latter may be taken as equal to that caused by a knee, the angle of which was equal to that which the clack lid made with the direction of flow of the water. Viewed in this light, the co-efficients given by Weisbach seemed to be excessively high.

Mr TELFER was sorry Mr Johnstone had not found any benefit from the air vessel. He might say he had had a lot of dook pumps, and in every case he had found a benefit from the use of an air vessel. He did not, however, think a small air vessel was of any use, although no precise rule could be given for the capacity, it certainly should be from six to eight times that of the plunger case. He had had sometimes two air vessels, but not so very far up in the column as Mr J. Moore had shown. He always found a great benefit from the air vessel, assuming that the pipes were smaller than the bucket.

Mr JOHNSTONE did not mean to say there was no gain from an air vessel. He merely wanted to point out that in the case referred to there was no gain; and from Mr J. Moore's remarks, he attributed this to its being too small, and the want of any means of re-charging it with air.

The SECRETARY remembered on one occasion having some little difficulty with an air vessel. Like Mr Johnstone, he had it duly charged with air when they started, but through gradual working the air got exhausted, and the air vessel was filled with water. What drew their attention to it was a slight knocking in the discharge pipe at a bend at the pit-mouth. The knocking gradually increased, and for some time they could not find out what was wrong, and as a last resource they emptied the pipes and examined the clacks. They were all right, and on starting the engine the knocking ceased. He thought there was no doubt they had lost the benefit of the air vessels, and that they had got re-charged with air which enabled them to do their duty. He was very much pleased with the arrangement Mr J. Moore had sketched for re-charging air vessels; it was a simple arrangement, and could be easily attached to any air vessel at a moderate cost.

The discussion on the paper was afterwards adjourned, and on the motion of Mr M'Creath a hearty vote of thanks was accorded to Mr J. Moore for his presence and the information he had conveyed.

DISCUSSION ON THE PRESIDENT'S PAPER ON A SELF-TIPPING CAGE AND GUN-BOAT.

THE PRESIDENT, in inviting discussion on his paper descriptive of a self-tipping cage and gun-boat, said he had got a drawing of another arrangement somewhat similar, which he would have to trouble them with in a month or so.

Mr BARROWMAN said there was one little matter he was not quite clear about with regard to the tipping cage, viz., in the act of tipping, what was it that prevented the car slipping off the cage.

The PRESIDENT said the catch on the top was perfectly sufficient.

Mr DIXON remembered when out in Sweden, some years ago, seeing an appliance for the same purpose, but of a different arrangement. The mines went down at an inclination of 70 degrees. The hutch was filled at the bottom of the mine, and it had a hinged bottom which was opened when it reached the top, and was knocked up again and fastened with a catch as the hutch commenced to move down the mine.

Mr ANDERSON asked how this arrangement stood for each man getting his own coals.

The PRESIDENT said the cage was filled at the bottom from hutches holding three to four tons, which went into the face.

Mr DIXON would like to hear about the applicability of the cage to this district.

The PRESIDENT said the gun-boat seemed to him to be very applicable to steep inclines such as the edge seams.

Mr BARROWMAN said there was one disadvantage with regard to the gun-boat, viz., the double turning over of the coals which would cause more breakage.

The PRESIDENT—No doubt of it; but in those long inclines at a steep angle the difficulty was to get a quantity put out. There was no difficulty with this gun-boat in drawing a thousand tons a day perhaps a thousand yards, because they could run at a greater speed.

Mr DIXON thought it would be applicable to gas coal, ironstone, and the edge seams near Edinburgh.

The PRESIDENT—There is this disadvantage, you are not able to keep the same look out upon the cleaning of the coals.

Mr ANDERSON—The coal is much harder, and they want it broken up at any rate.

The PRESIDENT—The coal is nearly as hard as gas coal—some of it is harder, and will cut your hand. It is all broken up into pieces by means of machinery.

The discussion was closed with a vote of thanks to the President proposed by the Secretary.

BLASTING BY LIME.

The results of some trials with Messrs Smith & Moore's Patent System of Getting Coal at Earnock Colliery, Hamilton.

BY THE SECRETARY.

In the beginning of the present season the Council appointed Messrs Barrowman and Hastie to visit Shipley Colliery, near Derby, and examine and report on Messrs Smith & Moore's Patent Method of Getting Coal. After hearing their report, the Council invited the patentees to send men and material to make trials of their system in the different coal seams that are being worked in the district, but no notice was taken of the invitation.

Since that report was published, so many favourable reports had appeared in the Mining Journals and daily papers, that John Watson, Esq. of Earnock, was induced to arrange with the patentees to try the New Method of Getting Coal in the Ell coal seam at his Earnock Colliery.

Mr Oliver (Smith & Moore's agent) and other two men arrived at Earnock Colliery on Thursday, the 23rd November, and the following notes are the particulars of the trials made :—

As the system of drilling the necessary holes and using the lime cartridges have been already clearly explained, nothing further need be said under that head.

When the men arrived they were at once taken below to the place where preparation had been made for the trials.

It was at a part of the mine where stooping had been going on for nearly three months. The place selected for the first trial was the first lift from the side of a stoop next to a large barrier of coal which is being left in for a special purpose.

The place was holed 5½ ft. for 13 ft. along the side of the stoop.

When Mr Oliver saw the place which had been selected and prepared, he expressed himself highly satisfied with it, and at once started his men to drill three holes. The first hole was put in 4 ft. from the corner of the stoop—it was 3 inches in diameter, and 3 ft. 3 in. deep. It took seventeen minutes to put it in. The second hole was four feet from the first, and the third was also placed four feet from the second. The holes were all placed near the roof—in fact, just in the same position as if the coal were to have been blasted with gunpowder.

After the three holes were all drilled in 3 ft. 3 in. they were charged with lime, 29 inches of lime being put into each hole, and the rest of the hole stemmed up in the usual way.

As the trial was only considered a preliminary one, no note was taken of the time it took them to charge the holes or of the time which elapsed before the sprags were withdrawn ; but the result, when the sprags were taken out, was that only a piece of coal came down at the corner of the stoop weighing about 30 cwts. The second and third holes were not even broken. The writer was very much disappointed with the results, but Mr Oliver said that he was satisfied with the trial, and felt so confident that he would bring down the coals next day ; that he asked him to invite as many gentlemen as possible to come and see the trials made. This was agreed to, and the following gentlemen availed themselves of the opportunity :—Messrs Smith

and Bishop, Cadzow Colliery; Hastie, Greenfield Colliery; Blyth, Bent Colliery; Park, Allanshaw Colliery; Smart, Forniegair Colliery; and Telfer, Overtown and Law Collieries.

The trial which took place on the 24th was in a different part of the mine. It was in what is called a splitting place—a place going through a stoop already formed.

The coal at this particular place is very hard and difficult to get. The place was 13 feet 6 inches wide in the holing and 12 feet 6 inches wide at the roof. The coal is 7 feet thick, 5 feet of which is brought down in the first working, and the remaining 2 feet is lifted as the road advances. The place was holed 6 feet deep, and had been standing holed for two days. Mr Oliver wanted it cut on one side so as to get an open end, so the collier who prepared the place cut or "sheared" it in for 6 feet that morning. Mr Oliver's men drilled three holes in this place, each 3 feet 3 inches deep, and charged them with lime, and when sprags had been put up to the face of the coal, they commenced to pump in water at fifty-three minutes past twelve o'clock. It took them two minutes to charge the three holes with water.

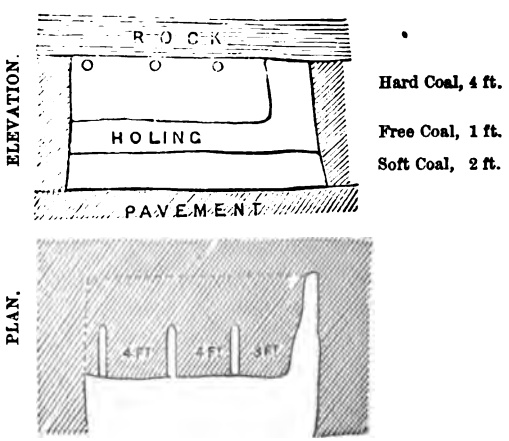


FIG. 1.

Fig. 1 shows how the holes were placed and the distances between them.

Immediately after the holes were charged with water the coal

began to crack and craze as if it were going to tumble over, but it was in no way dangerous to remain beside it. The sprags were drawn at forty-five minutes past one o'clock, or fifty minutes after the holes were charged with water, and only about 30 cwt. of coals came down, or about one sixth of the coal expected to be brought down. One foot of the hole next the "shearing" was left on and two feet of the second hole; the third hole did no work at all.

When the coal came down, the lime that was in the first hole had not apparently got enough of water, and the result was that the lime became a very fine impalpable dust and filled the whole place. It was worse than powder-smoke, in fact was as bad as the fumes given off when a charge of dynamite is fired.

Mr Oliver was so dissatisfied with the day's results that it was arranged to make another trial next day, and for that purpose a fresh place was prepared at the stoops where the first trial was made.

Messrs Barrowman and Beith witnessed the trial made on the 25th. The trial place was holed 5 feet deep; the first hole was drilled 6 feet from the corner of the stoop, the second 4 feet 9 inches from the first, the third 5 feet from the second, and in this case a fourth hole was drilled 16 inches from the third, but 16 inches down from the roof; the object of the fourth hole being so close to the third and so far down from the roof was to try and break the coal from the "rib" or fast side.

In order to make this trial successful, a longer drill was made to suit the machine, so as to enable deeper holes to be drilled and allow more lime to be put into each hole. The two first holes in this case were drilled 4 feet, the third hole was 3 feet 6 inches deep, and the fourth 3 feet 3 inches deep. Each hole was so filled with lime cartridges that only 10 inches was left for stemming.

It took two men one hour and forty minutes' hard work to drill the four holes. After charging the holes in the usual way, they commenced to pump in water at forty-two minutes past twelve o'clock, and the sprags were drawn at forty-five minutes past one o'clock, but no coal came down. The coal was parted from the roof at the corner, and was afterwards brought down by wedging.

In this case one foot of the first hole was left on and three feet of the second, while the third and fourth charges did nothing, as shown at A.B. in fig. 2.

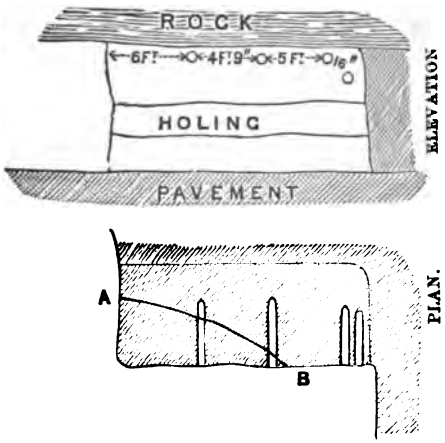


FIG. 2.

The PRESIDENT would like to know what was the action of the lime. Did it seem that the lime acted but that the gas or whatever it was expended itself through the joints of the coal; or did it seem that the work was actually done?

The SECRETARY—The coal was far too strong for the lime. There was no escape in any way nor any loss.

The PRESIDENT—What made me ask was, you said that it began to rend.

The SECRETARY—Crack and craze, but there was nothing else.

Mr DUNCAN said it would be interesting to know whether the patentees could account for the failure in any way themselves. Did they give any reason for the failure in this particular case, seeing it was said to be a success elsewhere.

The SECRETARY said the agent of the patentees admitted the coal was too strong.

Mr ANDERSON said, seeing there were so many gentlemen from the collieries round about, they would be able to say if there was anything exceptional at Earnock, and if the coal was stronger than in the other collieries.

Mr SMART saw the process, and he thought it got every chance. The coal seemed to be very regular. There was nothing difficult about it. After the charge began to work, the coal gradually began to separate from the roof along the whole face. The crack was widest at the open end, where it had the least resistance. It was expected to be down in half an hour, and they gave it twenty minutes more. There was nothing in the coal, he should say, that could have hindered it coming down. It was well shorn and well holed, and seemed to part easily.

The PRESIDENT—Did the coal seem better suited at Ferniegair?

Mr SMART—I do not think it would have done so well at Ferniegair. At Earnock, they had a rock roof, while at Ferniegair there is a coal parting.

Mr BLYTH said it was similar at Bent.

Mr PARK—I do not think it would have done at Allanshaw.

Mr TELFER said his opinion was that with a fourth hole, if it had been tried, it would have done better, yet it seemed it was no better the next day, but rather worse. The coal adhered pretty closely to the roof. The parting was bad.

The PRESIDENT—This report showed the wisdom of the Institute sending deputations of their members to investigate new inventions, and in sending the proper men. In this paper they had a complete corroboration of the report of their deputation. He had not, in one sense, felt more satisfied at anything than to see their report so completely verified. He was sorry to find that the system was not a success; and while there were many seams where it could be useful, it was very evident that in the Hamilton seams it would not do.

Mr ANDERSON endorsed what the President had said regarding the members of the deputation. The opinion they expressed was in a measure dragged out of them. They were very reluctant indeed to say anything that could damage the prospects of the patentees. They had acted with great prudence, and these tests at Earnock had verified their statement. He thought the Institute was much indebted to the proprietor and manager of Earnock for, at their own expense, having this system put to the proof in the district. It proved there need be no further experiment made in the Hamilton district with this patent process.

The PRESIDENT, as trials had been made in Fife, suggested the adjournment of the discussion until the result of them was known.

Mr DRINNAN thought too much credit was being taken to the Institute in the matter. He thought Mr Anderson had really hit the right nail on the head when he said Mr Watson of Earnock was entitled to a good deal of the credit of having proved the value of the report of their deputation, which would never have been known but for Mr Watson, who had been at the necessary expense of bringing those people there.

Mr SMART might say, as shewing what the men thought of the process, Mr Gilchrist said to the miner in charge—"If you give me 1d per ton off your labour, I will get machines for you and get you a start." The man did not accept his offer.

The discussion was then adjourned, and the meeting separated.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 11th JANUARY, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Twenty-seven members were present at the meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members:—

JOHN CONNAL, Coal Salesman, 123 St Vincent Street, Glasgow.

ALEXANDER RUSSELL, Manager, Dalmeny Oil Works, Broxburn.

Other five gentlemen were then nominated for election, and will be balloted for at the first meeting.

DISCUSSION OF MR ROBSON'S PAPER ON EXPLOSIONS OF FIRE-DAMP.

The PRESIDENT having introduced the discussion,

Mr DRINNAN said he would like to say a few words with regard to some remarks by Mr Gardiner on the paper. In these remarks Mr Robson is taken to task for using loose and vague expressions. Now, I think Mr Gardiner has himself fallen into the same error. At p. 210 Mr Gardiner says:—"The text of the

paper has a tendency to convey a wrong impression of the constituent parts, as well as the characteristic points when mechanically mixed with other gases." In order to have made this a lucid expression, it should have been stated that it was the constituent parts of the gas, and not the paper that was referred to. A little further down he spoke of it (marsh gas) as "the richest and the lightest of hydro-carbons." He (Mr Drinnan) thought it would be well to know from him in what it was richer than the other hydro-carbons, as it was a well-known fact that olefiant gas was richer in carbon than marsh gas. A little further down still, he said, "Marsh gas was generated in the formation of coal." He thought it was altogether a misuse of language to speak of free nitrogen being generated. When they spoke of anything being generated, they spoke of it being created or called into being, but free nitrogen was not called into being — it had an existence already. With regard to compounds, we might be said to generate them, but when used in reference to free nitrogen, it would be as correct to say we had generated mud when we had filtered dirty water. He failed to see how the pit referred to by Mr Gardiner on p. 213 could be considered well ventilated. He rather held with Mr Robson in his definition of what was and what was not a sufficiently ventilated pit.

Mr GARDINER did not understand what Mr Drinnan meant by his first objection. As to the second, in reference to the richness of the hydro-carbons, it is the hydrogen that gives the wealth. The gas (marsh gas) has four atoms of hydrogen to one of carbon. No other hydro-carbon compound has so much hydrogen in combination with carbon; consequently, marsh gas is always called the richest of the hydro-carbons. Next he referred to the generation of nitrogen. Nitrogen is generated —although, perhaps, liberated is better—in the decomposition of the vegetable matter in the formation of coal. It was present in the air that would be enclosed with the organic substances that form coal, in the re-arranging of the elements into the gases found in coal the nitrogen is set free, and is only found as free nitrogen in coal. As regards the other point—the ventilation—he was still of opinion that it did not follow that a pit

was badly ventilated when a small accumulation of gas took place. As an illustration they might have a good current of air sweeping round the face, and a blower be struck or cut in the shearing. In the case he referred to, the explosion had taken place in the main aircourse, where a fall had been. The pit was well ventilated. Mr Gardiner concluded by pointing out a mistake at the third line from the bottom of p. 210. Carbonic oxide was not generated in the formation of the coal.

The PRESIDENT rather thought Mr Drinnan was right; nitrogen was merely liberated and not created. However, that was not a very great matter. It had always struck him that the best definition of a well ventilated pit was that given in the first general rule, viz. :—"That so far as is reasonably practicable, an adequate amount of ventilation shall be constantly produced in every mine, to dilute and render harmless noxious gases to such an extent that the working places of the shafts, levels, stables, and working places of such mine, and the travelling roads to and from such working places, shall be in a fit state for working and passing therein." He could not agree with Mr Gardiner that his pit was well ventilated; because he might have got rid of his accumulation of gas by means of a "hurdle screen." Whenever falls were likely to occur they should always be ready with such appliances so as not to allow accumulations of gas of that kind when they could be readily dispelled.

The discussion on the paper was then closed, and the President proposed a vote of thanks to its author.

DISCUSSION OF MR M'CREATH'S PAPER

ON THE SUCKING POWER OF THE COMMON PUMP, AND ON SOME OF THE SHOCKS THAT OCCUR IN PUMPING.

The PRESIDENT having invited discussion on this paper,

Mr M'CREATH said that towards the end of the paper he said he could not take up the question of shocks fully for want of time. The shocks that he meant to take up were only those that were caused by the working barrel not being filled with water,

and no other shocks: and when the President asked him if the very valuable information that Mr Joseph Moore gave them was not at variance with that theory, it appeared his impression was that he meant to refer to such shocks as Mr Moore found the air vessels prevented. Shocks which he conceived the air vessels prevented were first the shock that would take place from the ram being suddenly applied to move a column of 18,000 feet of water—equal to about 3½ tons on the square inch of the area of the pipe; and the other shock which he would have had would be:—if the clack did not close quickly at the end of the stroke, part of the water would return and flow through the clack until the sudden closing of the clack stopped it and created the shock. Where there was an air vessel well filled with air near the working barrel, the ram had only a few feet of water to move into the air vessel. That did not require a great deal of force, and the water would partly continue to flow into the air vessel until the pressure raised in the air vessel and the time were sufficient to drive the water before the ram at its own speed. If the clack did not shut at the end of the stroke, then the water passing through it would be supplied altogether from the air vessel, and the water would continue to rise in the main column and there would be no fall of the column and no shock, excepting between the air vessel and the clack; so that he did not think that the useful effect that was found from these air vessels was at all at variance with the theory he brought forward. He might say he was also very much pleased to learn from what was mentioned by Mr Joseph Moore, that an air vessel could be replenished with air by merely "driving the pump on air," provided the air vessel was put in such a place as would catch any air that came up with the water. He had occasion a few days after last meeting to be in a mine where they had started a force pump to raise water up an incline a distance of about 300 fathoms and upwards of 40 fathoms vertical. They had made no provision to replenish the air vessel, and burst four or five pipes, one after another, when the mechanic thought of slackening one of the joints of the suction pipes and giving it a little air, and after that the pump worked more smoothly, and there were no more breakages.

The PRESIDENT thought the late Robert Aytoun, of Edinburgh, who was a great amateur in pumps and other mechanical contrivances, proposed to have an air pipe in connection with the suction, so that at any time he might send air in for the same purpose; and it was a very old contrivance indeed, in suctions, when a pump was knocking very much, to send a little air into the suction. He had read somewhere that by letting in air along with the suction it was possible to lift water more than 32 feet. This was simply because the column was composed not of water only but of a mixture of air and water.

Mr ROBSON, with reference to the shocks, would like to ask the members who had had experience in the matter, if it was not the practice to make the metal very much thicker near the bottom, to guard against breakage by the various shocks. What was the factor of safety?

Mr DRINNAN said:—At p. 241, mid-way down, Mr M'Creath said that a pump with a uniform size of pipe must have, in order that it may clear itself of air, the height of the bucket at the top of its stroke above the surface of the water in the well so short, that the square of its half in feet shall be less than the stroke of the bucket multiplied by the number of feet of water, equivalent to the pressure of the atmosphere, provided that the clack between the bucket at the top of its stroke and the surface of the water in the well, or lower. Then, on the opposite side of the page an instance is given where the square of half the distance of the bucket from the surface of the water in the well is exactly equal to the length of stroke × by 32. He understood Mr M'Creath would mean that was the greatest height which water could be raised, when the atmosphere was of such a pressure as to be equal to 32 ft., and that he could not count upon that at all times; but he wished to know whether Mr M'Creath did not think there might be something in the velocity of the water,—whether something could not be gained by that. He had observed sometimes that when the pump would not take the "fang," as it was called, by giving two or three quick strokes it would sometimes take it. I understand that the rule here given by Mr M'Creath is based on the reason given at top of page 241, where the bucket being 20 feet above the water in

the well, length of stroke 2 feet, and clack 16 feet above the water, he assumes that the water would never rise to the clack, because when the bucket was at the bottom of its stroke there would remain two feet of air between the bucket and the clack, slightly above atmospheric pressure, due, I suppose, to weight of bucket lids.

Mr M'CREATH—Quite so.

Mr DRINNAN said therefore he assumed Mr M'Creath's meaning was, that though when the bucket was at the stroke, this two feet of air would have double the space, it would scarcely be equal to half a vacuum, owing to air's previous compression by weight of bucket lids.

Mr M'CREATH—Quite so.

Mr DRINNAN asked if there was not something in the velocity that might occur by the sudden stroke which would raise the water further.

Mr M'CREATH said he had not studied this view of the matter, but his present impression was that they had no power to create such a velocity by which it would rise higher than the pressure of the water. He would be inclined to think the driving of the bucket quickly for two or three strokes would merely prevent air getting in between the bucket and the working barrel in sufficient quantity to prevent the necessary vacuum being made.

The PRESIDENT said it was evident that, if the stroke of the pump were two feet, and the bucket were two feet from the clack when it was at the bottom of the stroke, that there could only be a vacuum equal to a half, because that was all the difference made, and the question was whether the water would not rise higher than Mr M'Creath had said under the circumstances. He asked if Mr M'Creath had anything to say to Mr Robson's question?

Mr M'CREATH said his impression was the factor of safety was 16 to 20.

Mr JOSEPH MOORE said he did not understand that this discussion applied to more than the theory of the pump. Of course they always made it very much stronger. They made such cast-iron barrels as that with a strain of 600 lbs. to the sectional inch, although they usually considered 2000

lbs. to the sectional inch was sufficient for the pipes. Scotch cast-iron runs about 18,000 to 20,000 lbs., and usually in making machinery they considered 2000 lbs. to the square inch very fair. For the heavy machinery he mentioned as having made, they used American cast-iron, the breaking strain of which was 36,000 lbs. to the square inch, and they worked that under 4000 lbs. to the square inch (which was a very extreme case), and had no breakages. At the same time they had had parts broken which were strained to 3000 lbs. per sectional inch. He would not put up another piece of machinery above 2500. He took advantage of the high quality of the iron, but sufficient allowance was not made. There were breakages where such ought not to have been.

The PRESIDENT—In short, the iron ought not to be strained above one-twelfth.

Mr JOSEPH MOORE—I think not. When you come between the clacks and the valves, it is too high. You must keep down then to 600 or 800.

The PRESIDENT—That is a thirtieth.

Mr JOSEPH MOORE—We have it at that. As to the shocks, they were correct to a certain extent. Of course, they had to take into consideration the amount of water between the bucket and the air vessel. If they made the vessel large enough they had little pressure on the chamber.

Mr PRENTICE said he had been much struck with the usefulness of the vacuum chamber. He would like to ask, did the reverse of what happened in the air vessel not take place in the vacuum chamber? He meant, did it not gradually get filled with air and lose its utility in that way? He would expect if the distance from the water in the well to the pump exceeded 10 ft., the water would gradually part with any air it might have absorbed, and this air would be likely to find its way into the vacuum chamber.

Mr JOSEPH MOORE pointed out that any air in the vacuum vessel would be at a less pressure than the atmosphere.

Mr PRENTICE, referring to Mr Robson's question about the strength of pumps, said that where these were made for ordinary lifts of 60 or 70 fathoms, it was sometimes the practice to subject

the well, length of stroke 2 feet, and clack 16 feet above the water, he assumes that the water would never rise to the clack, because when the bucket was at the bottom of its stroke there would remain two feet of air between the bucket and the clack, slightly above atmospheric pressure, due, I suppose, to weight of bucket lids.

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[redacted]

the casing, passages, and clack-seats to a testing pressure of 600 lbs. per square inch, and this pressure kept up for 24 hours; and where the ordinary working pressure did not exceed 200 lbs. per square inch, it was generally considered safe if it stood successfully a testing pressure of 800 lbs. per square inch. He was afraid it would not be quite safe at that for some of the strains Mr M'Creath spoke of. One pump, at present working under his supervision, had an ordinary working pressure of 180 lbs. per square inch—had been subjected for 24 hours to a testing pressure of 600 lbs. per square inch—and, at the time it was put in, it was considered pretty safe for ordinary work.

The PRESIDENT, in adjourning the discussion, mentioned that Mr Grant, Kilmarnock, was to deliver some remarks on water-works which he had been erecting.

DISCUSSION OF THE SECRETARY'S PAPER ON BLASTING BY LIME.

The SECRETARY read as follows:—

"In answer to your letter of the 21st Dec., with reference to the experiments made at Muircockhall Colliery with Messrs Smith & Moore's patent method of coal getting by the use of compressed lime cartridges, we have to state that the experiments were not so successful as we anticipated. We made the trial in our three feet seam, which is of rather a soft and friable nature, and has a very bad "parting" and a hard fire-clay "holing." The coal was holed in about 3ft. 6in., and bore holes every 6 ft. Holes were bored in 3ft. 2in., and were 3in. dia. Each hole contained seven cartridges or 8lbs. of lime, and occupied a space of 28in., which left a space of 8in. to 10in. for the "stemming." The water was then applied in the manner already described in the report to the Institute of June last. Then, in half-an-hour's time, the sprags were taken out, and the coal came down. At two of the holes the coal did not come clean away from the parting, owing to the

drill being placed too low and not touching the roof. On comparing the two blasting agents—viz., gunpowder and lime, there was hardly any appreciable difference; if any, it was rather in favour of the powder. We had about 75% of round coal with the lime, and that is just what we reckon to have when using powder. We believe, however, that the coal brought down with the lime is not quite so brittle as with powder, and would stand handling better. Possibly, had there been less lime employed, the result might have been more favourable—say, about 6lbs. of lime in each hole. As to the cost, the lime would be a little more expensive,—lime put into each hole cost 3½d. Arrangements are being made to make the cartridges on a larger scale, so as to reduce the cost.—We are, yours faithfully,

THE WEST OF FIFE COAL COMPANY."

The SECRETARY said it would possibly be as well to remind the meeting that the patentees did not pretend to put their system against powder. They expected that it would come into force where powder had been prohibited.

The PRESIDENT thought they did say that there would be a larger proportion of round coal where the lime was used than there would be with powder.

The SECRETARY—They compare it with wedging.

Mr BARROWMAN said the patentees themselves did not compare it with powder, but in a paper read before the Iron and Steel Institute, Mr Mosley, who, he understood, was one of the proprietors of the Shipley Colliery, said that the process patented by Messrs Smith & Moore had for one of its objects:—to take the place of blasting by gunpowder or dynamite.

The PRESIDENT—I think the patentees say the yield of round coal will be so much greater?

The SECRETARY—Where the coal is well prepared, I have seen it brought down in a solid block across the whole of the face with powder, and lime would not have done any more than that.

The PRESIDENT—Then there is no difference so far as the yield of round coal is concerned between this method and that of using gunpowder.

The SECRETARY—So far as I saw it that is so.

The PRESIDENT—Then they certainly claim that there was much more round coal than with wedging.

Mr HASTIE—It did not bring down any coal at Earnock at all in some cases.

The PRESIDENT—What they wanted to get at was, was the proportion of round coal greater or less than when blasting with gunpowder? There seemed to be no difference, but it struck him the patentees held out that there was less small by this process than by wedging.

Mr ANDERSON—I think they said 2 per cent.

The SECRETARY—Mr Oliver did not compare it with powder.

Mr M'CREATH—Have you compared it with powder?

The SECRETARY said where the trial took place on the Friday—the second day—three quarters of a lb. of powder would have brought down the whole of the coal. In this case they had to bore three holes for the lime, with powder one hole would have been sufficient. Cost of lime used 10½d. At the trial made next day they bored four holes and charged them with lime costing 1s 4d. If powder had been used two bore holes with half a pound in each would have brought down the coal. Powder costs 4d per pound.

The PRESIDENT—How much more dross would you have had by the one process than the other?

The SECRETARY—In the case where the coal was so well prepared I would not have been surprised to see it brought down all in a piece. I have seen it done often.

The PRESIDENT—You will see those gentlemen make a remark.

The SECRETARY—Yes; they say "we believe that the coal brought down with the lime is not so brittle and would stand handling better." Unless where it came in a solid lump this was a true remark, but where it was solid they required to break it with the picks.

The PRESIDENT—Do I gather that there is really no difference between the two processes as regards the yield of round coal, or, if any, it is in favour of gunpowder.

The SECRETARY—No; I would say if the lime had been successful it might have been about equal.

The PRESIDENT—There was no patent right?

The SECRETARY said the patentees supply the tools necessary at the following rates:—Drilling Machine, with pair of bits complete, £4; Hand Pump, with stirrup, flexible hose, and patent coupling, £2; Hydraulic Tubes, perforated, slotted, and annealed, each 1s; Steam Taps, with nozzle to receive coupling, 1s 6d; Grooved Rammers, 2s 6d; Buckets, galvanized and painted to indicate charges, 2s; Hand Cartridge Boxes, 2s; Each Charge, consisting of 7 discs, weighing 8 lbs., and calico bag, 3½d.

Mr LOVE—I understood there was a royalty on the boring machine?

The SECRETARY—No.

The PRESIDENT—Is your deduction that, if anything, powder is cheaper than this lime?

The SECRETARY—Oh, certainly where you could use it. Our object was that we might use it where we did not feel ourselves at liberty to use powder.

The PRESIDENT—After all, unless it is in the labour, the difference per ton between the lime and the powder is very trifling.

The SECRETARY—Nearly 1d per ton.

Mr BARROWMAN did not know that the trials had been sufficiently numerous to justify a comparison of the amount of round coal produced by the two processes.

The PRESIDENT—The Secretary says, in his opinion, the coal could have been wholly taken down by a quantity of powder, and if they had taken it down with the lime the difference in cost was not so much as to have prevented them from adopting the system, the results in round coal being the same. Mr Barrowman is quite correct in saying we had no other data but the Secretary's.

Mr GARDINER said he had noted down the results of two different experiments in England—(reads).

The following is from a paper read by A. Sopwith, Esq., M. Inst., C.E., and certificated manager of Cannock Chase Colliery:—"A general analysis of the foregoing leads to the conclusion that for bringing down coal in a long-wall face which is undercut the process is successful; out of four experiments only one was a failure, and this, as explained, is to be accounted for. It would be manifestly unfair to condemn the

process so far as getting coal in a head is concerned, by the failure of one experiment." . . . "There is no doubt that much less slack is made by the lime process than in blasting by powder," and as regards the cost in this case he states, "I find that the difference would amount to 1½d in favour of the lime." . . . Again, referring to an experiment conducted by two men in the employ of the patentees, at Great Wyrley Colliery, on 22d December, 1882, the paper states that "they operated on one of the most difficult places in the pit, viz., 'a fast end' of the face, of the length of 34 feet. The coal, which was five feet thick, was holed to a depth of four feet, and had been on the sprags thirty-six hours. Six holes were drilled in the face of the coal to a depth of three feet three inches. The holes were three inches each in diameter, five of them five feet three inches apart being close to the roof, and the other eight-and-a-half inches below." The holes were charged with lime in the usual way and water to the amount of about a couple pints were forced in. The water oosing through the holes *saturated* the lime." In three minutes cracking of the coal was heard, and in half-an-hour the sprags were drawn by a collier, and from 15 to 20 tons of coal came down. "It was nearly all in large lumps, one piece weighing about six tons, and there was little or no slack. It was feared that the lime would mark the coal and destroy its distinguishing features, but on examination it was found that only in one instance had the lime spread, and that was where the coal had cracked. In the other five cases the lime had simply expanded in the hole to the extent of half-an-inch, and the greater portion of the charge adhered to the roof." Altogether the experiment was considered by those present to have been most successful. In these, as well as in all experiments by the lime process, with one exception, in North Staffordshire where the roof was soft, that I have noticed, the process has been attended with success less or more. In the Great Wyrley and Earnock experiments, there are many points that are common—the thickness of the two seams, also the average distance between the holes, and the arrangement of the holes being the same; the principal difference being—in Great Wyrley that the coal had been holed for thirty-six hours and spragged, whereas at Earnock the coal was newly holed. This

might have caused the difference in the result. But Mr Gilchrist states that the lime was not saturated, but only reduced to powder, and that it filled the whole place with dust. I find, in referring to Mr Sopwith's paper, 168 cubic inches of lime were put in each hole, and 122 cubic inches of water pumped in. About two pints of water is stated to have saturated the lime at Great Wyrley. Let us look at it from another point—the breast of coal to be broken down at Earnock Colliery had an area of 14,000 square inches, without taking into consideration the area of roof parting. The power exerted, or ought to have been exerted at Earnock was 3357 tons, or 530 lb. per inch. I have little hesitation in stating that is too little, as ordinary good cement has a tensile strain equal to 400 or 450 lb. per square inch.

Mr M'CREATH said in the paper before the Iron and Steel Institute the pressure was said to be 2850 lbs to the square inch. It might be well to compare that if they could with the pressure that arose from the explosion of gunpowder. He did not know if that had been ascertained for blasting powder, but in a paper by Captain Noble and Professor Abel they said when the hole was filled with solid powder there was a pressure of about 42 tons to the square inch or 94,000 lbs., and the temperature was about 4000° Fah.

Mr GARDINER said more water should be pumped into the holes to saturate the lime than had been done at Earnock.

The PRESIDENT—It would be difficult to ascertain the pressure.

Mr HASTIE said whenever the pressure began, by turning the cock thay would know it that way.

Mr M'CREATH—Whenever the pressure was taken off the temperature would fall.

The PRESIDENT had always an idea if they introduced water say at 2000 lbs. in the square inch into the hole and made it tight by means of india-rubber, they would by that pressure bring down the coal just as effectively as by lime or powder or any other means. Suppose two pistons the diameter of the hole were connected by a pipe 2 feet long, with a hole in it. By introducing this into a 3-inch hole, and pumping water in between the two pistons, the requisite amount of pressure could be got,

while the one piston would balance the other (Fig. 1), and there would be no tendency to be blown out, however much pressure

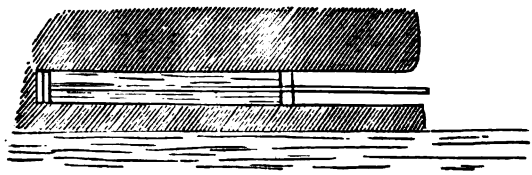


Fig. 1.

were applied. Sir Wm. Armstrong, he thought, used pumps or hydraulic pressure for meeting the recoil of his heavy guns up to 4 tons to the square inch.

Mr Joseph Moore—I use 5 tons to the square inch.

Mr Barrowman observed in all the experiments mentioned they had waited a considerable time before they drew the sprags. He was inclined to question the benefit of that. He rather thought the force of the charge—both the steam and the lime—was past in a much shorter period than the period they usually allow.

The President—I suppose the object of keeping the sprags in will be to break the coal at the back end.

Mr Drinnan was somewhat interested in what Mr Gardiner said about the amount of pressure that would be obtained by these charges. He would like to know again how Mr Gardiner calculated the amount of water to be absorbed into that pressed lime to allow a calculation of the pressure upon the coal. That was a necessary thing to ascertain the pressure.

Mr Gardiner—The same capacity of water as of lime.

Mr Drinnan—Then what is the bulk? Is it doubled?

Mr Gardiner did not take that into consideration. The water would be changed into steam. That was where the pressure came from.

Mr M'Creath asked what temperature did Mr Gardiner assume to get the pressure calculated. It seemed to him necessary to know the temperature in order to arrive at the pressure of steam.

Mr Gardiner did not take the temperature—just enough to make it into steam. The following is the formula I based my

calculation on, Molesworth's pocket-book, p. 237 :—$V = \frac{20,559}{p.-941}$ = volume of steam from 1 cubic foot of water; p. = pressure in lbs. per square inch, atmosphere included.

Lbs. per sq. inch.

Note.—1 Cub. Ft. Water converted into 1 Cub. Ft. of Steam in same space, ... = 22,000.
Pressure developed by Gunpowder complete combustion = 173,155.
Do., do, in complete do. = 66,663.
The relative strength bulk for bulk of the following explosives are—
Gunpowder, = 1·00. Gun-Cotton, = 2·57.
Dynamite, = 4·23. Nitro-Glycerine, = 5·71.

The PRESIDENT—Would it not be necessary to take the temperature?

Mr GARDINER—The heat given out in the hydration of lime has been estimated at more than 570°—sufficiently high to inflame gunpowder. Pelletier observed that "in slaking lime, in large quantities, in the dark, light was evolved as well as heat." It is considered in the slaking of lime the latent heat of water is set free (966°).

The SECRETARY—If Mr Gardiner had made the experiment he would have come to a different conclusion altogether.

The PRESIDENT—What stemming was there in each hole?

The SECRETARY—From 8 to 10 inches.

The PRESIDENT—Would that make a tight stemming for the pressure you are calculating?

The SECRETARY—It depends upon how the stemming was put in.

The PRESIDENT—But the one is instantaneous and the other gradual.

Mr R. T. MOORE—The quantity of water which quicklime absorbs in being converted into slaked lime may readily be got from the chemical equation representing the reaction—56 parts by weight of quicklime, absorbing 18 parts by weight of water to become slaked lime.

The PRESIDENT—What does it make?

Mr R. T. MOORE—The oxide of lime combines with water to form the hydrated oxide. The results of this combination are an increase in the bulk of the substance and heat. This heat turns any superabundant water into steam, and it is to this and

to the expansion of the substance that the power of the lime is due. In order to calculate the pressure we would require to know the temperature of the steam.

Mr GARDINER—Quicklime—that is, the state the lime is in the cartridges—is an oxide of lime (Ca O) without water. Slaked lime—that is, after one-third by weight of water is added—is (Ca O H_2 O), an oxide with water, and is a dry powder, as that described by Mr Gilchrist in the Earnock experiment. The additional water being added, steam is made, and no doubt is in the virtue in the lime process.

Mr BARROWMAN—It is said by Mr Mosley to expand five times. He (Mr Barrowman) once experimented and found, in putting in an open vessel an equal quantity of water to the lime, the result, after slaking, to be that it was four times the bulk of the original cartridge.

Mr M'CREATH—If you applied pressure, would it have reduced the bulk?

Mr BARROWMAN did not think it would have reduced it much. There was a violent ebullition some minutes after the water was added for two or three minutes. After the boiling stopped, the lime was a solid unyielding mass.

The PRESIDENT—Suppose you put one of these cartridges into a pipe and filled it with water and kept up the temperature, would that split the pipe?

Mr BARROWMAN—Yes, if the ends be stopped. Mr Mosley, in his paper, refers to a pipe which, after having been tested by water pressure to a strain of 953 lbs. per square inch, was burst with the lime.

The PRESIDENT—Well, but you have not made it clear whether it is the expansion in volume of the lime or whether it is the pressure of the steam.

Mr GARDINER—In every case in the experiments at Cannock Chase and Great Wyrley, the increased size of the hole was only half an inch.

Mr BARROWMAN—The steam is evolved as long as the boiling goes on.

The PRESIDENT—But if it occupied four times the space, then it was a wedge to all intents and purposes.

Mr BARROWMAN—This was in an open vessel.

Mr GILCHRIST—If there had been any great resistance it would have occupied much less space.

Mr ROBSON, as to the quantity of water being equal to the bulk of lime, rather thought Mr Gardiner was wrong. It would take a longer time to pump in bulk for bulk than was taken in the process.

Mr DRINNAN was of the same opinion. The question was—How much of the water was absorbed by the lime? It had to be chemically determined, and at first he was inclined to consider that all that was necessary was to determine the atom-fixing, or atom-replacing power of the several elements which were presented to each other. However, he did not now see how it was to be done at all, considering the conditions in which the hole was charged with water. He wished to ascertain from Mr Gardiner the reasons he had for coming to this conclusion. It was a question surrounded with difficulty and was not so easy as Mr Gardiner thought.

The PRESIDENT thought Mr Gardiner had been trying to arrive at some conclusion satisfactory to himself, but perhaps he might now see reasons to modify his conclusions. But what struck him was that it was not the steam at all, but simply the expansion of the lime—the altered bulk acting as a wedge and pressing down the coal. That is what is the claim of the inventor. If I heard the Secretary aright, he made the statement that the coal cracked and the steam escaped, and it then depended on the expansion of the solid lime.

Mr GILCHRIST—Yes, quite correct.

Mr SMART—Mr Barrowman gave us an idea how he tested it, and it became fixed in five minutes. Would not the lime after pressure become fixed in the same space of time, so that at the expiry of five minutes it would be unnecessary to extend the experiment to half-an-hour?

Mr BARROWMAN had the same opinion; but the behaviour of lime was perhaps different when excluded from the air.

The PRESIDENT, in closing the discussion, said it had been a very interesting discussion, and the subject was of great importance. Nothing further could be said until more data were got.

MANUFACTURE OF BLASTING GELATINE.

Mr DRINNAN drew attention to certain restrictions that had been imposed by the Government in the manufacture of blasting gelatine, and thought the subject worthy of the attention of the Institute. On the suggestion of the President, Mr Drinnan agreed to read a paper on the subject at a future meeting.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 8th FEBRUARY, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON.

Ralph Moore, Esq., President, in the Chair.

Fifty-three Members were present at the Meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members:—

JOHN WILSON, Coalmaster, Spittalhill Colliery, Newton.

A. CAMPBELL, Agent, The Redding Colliery Co., Falkirk.

WILLIAM POLLOCK, Cashier, Hamilton, M'Culloch, & Co., 88 Great Clyde Street, Glasgow.

JAMES GOODWIN, Manager, Gartness Coal Co., Airdrie.

JAMES HOWIE, Oversman, Blantyre Colliery, High Blantyre.

Other Twenty-three gentlemen were then nominated for election, and will be balloted for at the first meeting.

DESCRIPTION OF A NEW SAFETY LAMP.

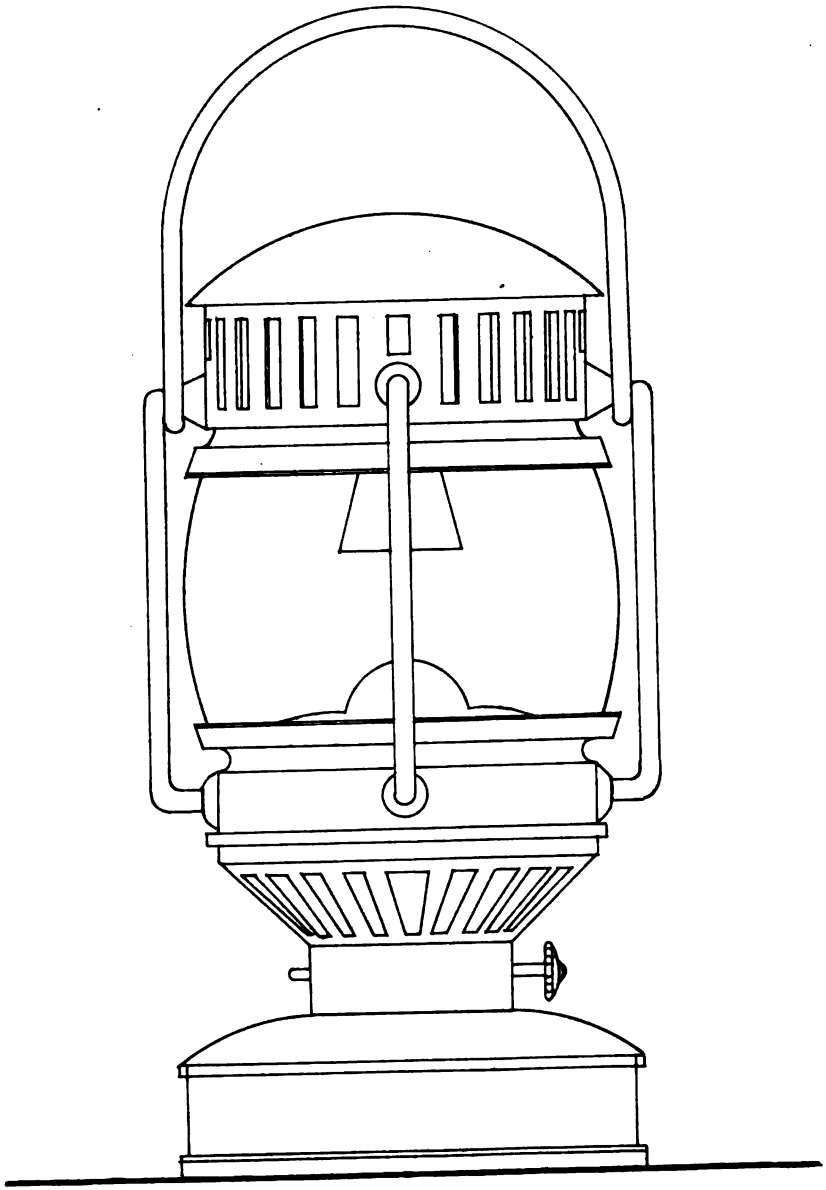
By DOUGALD BALLARDIE, Glasgow.

The report issued by the Royal Commission, appointed to inquire into Accidents in Mines, states in its detailed evidence a strong desire to have a better lamp for miners than any of those at present in use. Of the safety lamps employed in Great Britain the Davy, Clanny, Stephenson, Mueseler, and Teale's Protector, are by far the most largely used, the illuminating power of those varying from one eighth to nearly one half of that of a standard candle. The Royal Commissioners thought it necessary to announce to the Secretary of State for the Home Department that several of the safety lamps, when used in a current of an explosive nature travelling at the rate of six feet per second (nearly four and a quarter miles per hour), are attended with risk of accident almost amounting to certainty.

The various methods of locking the gauze to the lamp also called for attention. It was shown by the evidence brought before the Commissioners "that complication forms a serious difficulty in this respect." Some of the best authorities agree that there is greater danger from falls when safety lamps are used than when open lights are employed. This, undoubtedly, is because the roof cannot be so well seen, owing to the shadow of the top of the lamp.

It will be seen from the foregoing that the points required in "the better lamp" are:—*First*—The best possible light that can be got, or one at least equal to any light used in a mine. *Secondly*—Absolute safety in any explosive mixture of fire-damp, and power to withstand any current or sudden outburst of gas. *Thirdly*—A system of locking that is simple and perfect. *Fourthly*—A lamp to give a good top light to enable all using it to see perfectly the state of the roof.

Those various points have been kept in view in constructing the lamp now before you. (Plate V.) This lamp measures ten and a half inches in height, and weighs three and three quarter pounds when trimmed. Above the reservoir for oil it is divided into three compartments—the bottom for supply, the centre for combustion, and the top for exhaust. The bottom compartment is shut off



BALLARDIE'S SAFETY LAMP.

from the centre one by a gauze dome having the burner attached to it, and the centre compartment is divided from the top one by a solid metal diaphragm carrying a short funnel, which conveys the products of combustion into the top to allow their escape through the gauze-covered apertures round the sides. The bottom compartment is lined with gauze, and has a movable cover adapted for reducing the current through the lamp if necessary. The oil reservoir can be unscrewed from the lamp without interfering with the light, there being no connection between the upper part and this, except a small flat tube filled with the wick. The glass is blown glass, and in section shews a double convex lens, being about seven sixteenths of an inch thick in the centre, and about three sixteenths of an inch thick at top and bottom. It is well bedded in asbestos.

Let us now examine this lamp as to whether it meets the recommendations, and avoids the defects complained of.

First.—Light.—This lamp was sent to an eminent chemist to be tested in various ways and he gives its photometric value as 1·27 of standard candle. Its value in this respect, as compared to some others in use, is as follows :—

Standard Candle, ...	1·00
Common Naked Lamp, ...	1·80
Ballardie's Lamp, No. 1 Oil, ...	1·27
Young's Safety Lamp, Solid Paraffin, ...	0·74
Williamson's Safety Lamp, Solid Paraffin, ...	0·43
Williamson's Safety Lamp, Rape Oil, ...	0·35
Mueseler's Safety Lamp, Solid Paraffin, ...	0·38
Mueseler's Safety Lamp, Rape Oil, ...	0·34
Large Scotch Gauze, ...	0·45
Medium Scotch Gauze, ...	0·30
Small Scotch Gauze, ...	0·27
Clanny, ...	0·24
Davy, ...	0·21
Teale's Protector, ...	0·12

This lamp burns mineral oil known as "Young's No. 1 Oil." Specific gravity at 60° Fahr., ·806 ; and having a flash point at 120° open test, or 102° Abel test, Government standard of safety being 73° Abel test. When trimmed it holds half a pint, and burns steadily for twenty-two hours. The price of this oil

is eightpence per gallon, so that for eleven hours' burning the cost is one farthing. A comparison between this and the only other lamp that gives a light equal to it—viz., the common open light, the cost of oil for which is about one penny farthing for ten hours' burning—shows that this safety lamp gives as much light as the best open light at one-fifth of the cost, which is equivalent to a saving of about twenty five shillings a year on each lamp.

Secondly.—Safety.—This lamp has been put through a great many tests by myself, and also by parties having no interest whatever in the lamp. The following tests have been made with coal gas above ground :—The lamp has been placed under a glass shade, and a jet of gas turned on under the shade. The light burned until the gas seemed to have filled the shade down to the level of the bottom apertures, when the gas went into the lamp with the air and immediately extinguished the light. As a second test, a metal ring or tube pierced with twenty-four holes, each sending out a jet of gas, was passed over the lamp from top to bottom. When the ring got as low as the inlet holes the lamp was instantly extinguished. In passing the ring upwards, the lamp was again extinguished before the ring reached the inlet holes. A small room was prepared by closing all outlets that gas could escape by, and two jets of gas opened for an hour. The room was then entered quickly with the lamp. As in the other cases, the light was extinguished. The lamp has also been tested in fire-damp in a coal mine with the same result as above, viz. :—Whenever brought into contact with an explosive mixture the light was instantly extinguished.

Thirdly.—Locking.—When the top part of the lamp is replaced after lighting, two projections are brought together, and a small tapered lead bolt is placed in holes cut in each and squeezed down into the form of a snap-headed rivet by a pair of plyers having a movable screw die which stamps a letter or number on the top of the bolt. This mark can be changed daily, or as often as required. When a lamp is closed in this way it is impossible for any one to tamper with it without leaving proof sufficient to make detection inevitable.

Fourthly.—Lighting of Roof.—This is accomplished by the use of

a small reflector which forms part of the lamp, and is arranged to fall back to an angle of 45°. By this means a fourth part of the light is thrown up on the roof directly over the lamp, making that part so bright that in a six-foot working a newspaper might be read if placed on the roof. This reflector uses only the light that would be thrown behind when travelling, and when used at work gives the miner the advantage of having all the light thrown forward and at the sides.

There is another important feature in this lamp—viz., that of signalling. By a very simple arrangement in the bottom compartment, the presence of fire-damp or gas is indicated at any distance from where the lamp is placed. This is attained by passing a cotton thread through a small tube and fixing the end of it inside the lamp. With the outside end of the thread a wire or spring is tied back, and in this way divides a galvanic current. The moment gas enters the lamp, the thread is burned and allows the wire to fall back into its place and complete the current, which may keep a bell ringing till it is attended to. This arrangement seems invaluable for coal-laden ships, as it would instantly give warning when gas was accumulating in the hold.

The apparent advantages of this lamp may be summed up briefly thus :—*Light.*—By referring to the photometric table, it will be seen that this lamp gives nearly as great a light as any open light that is used in a mine. *Safety.*—Every test that has been applied and all the experiments made (which I propose to repeat before you after I read this paper) have proved the impossibility of passing a flame from this lamp. *Locking.*—By means of the simple arrangement now exhibited, a thoroughly efficient lock is obtained. *Light on the Roof.*—A fourth part of the light given by the lamp when thrown by the reflector on the roof is quite sufficient to enable the miner to examine it.

From what has been said, we may reasonably conclude (in the absence of actual practical use) that all the requirements for a safety lamp have been attempted to be met. An objection may be raised to this lamp from its not showing the presence of a small percentage of gas. In answer, it may be proper to state

that there has been no attempt to make this a fireman's or oversman's lamp. It is a miner's lamp—pure and simple—to give him the best light to do his work, and keep him safe while at it. An objection may also be made to the large surface of glass exposed. The common objection to this is of a two-fold kind:—the possibility of fracture caused by water falling on it, and the possibility of fracture from concussion. These possibilities have been fully kept in view in constructing this lamp, and the following tests have been made:—After burning several hours a quart of cold water was thrown over it. This has been repeated eight times by myself, and several times by others. Also, when the lamp has been fully heated it has been plunged into a bucket of cold water. This treatment had no effect whatever on the glass, as may be seen from the glass being intact. This is the identical glass used. As to the other effect—Concussion. From the form, thickness, and strength of the glass, it would be impossible for any small object striking it to break it, and any large object would either drive away the lamp or crush it completely. However, to secure it against any possible danger, a thin steel spiral gauze has been put over it, through which no dangerous object is likely to pass.

The necessity for safety lamps in mines does not need to be stated here. The very nature of the hazardous work requires that the best lamp should be used. "The better the lamp the safer the mine"—as one of the witnesses before the Royal Commission curtly put it—is a good text to put before you while examining the result of my humble efforts.

COPY.]

City Analyst's Laboratory.
128 Bath Street, Glasgow, 2nd Feby., 1883.

DEAR SIR,

I have examined your new Miners' Safety Lamp and tried a few experiments with it, the result being that I am very favourably impressed with it. The light it gives is excellent, and the description of oil used is cheap and easily procurable. Although in ordinary lamps the flame from oil of this kind is readily extinguished by a blast of wind, this is not the case with this lamp, as the orifices for the inlet of air are so small that even a strong wind produces very little effect. The

flame may, however, be extinguished by swinging the lamp about somewhat sharply. The safety of the lamp appears to be beyond all question, as the flame is at once extinguished when the lower part is filled with an explosive mixture. The novelty—or, at least, the leading novelty—in this lamp is that the explosion which extinguishes the flame takes place in the reservoir below and not in the lamp itself, and there is no elongating of the flame such as occurs in other lamps. In fact, the danger is past before the body of the lamp is charged with the explosive mixture.—I am, dear Sir, yours truly,

(Sgd.) WM. WALLACE.

Mr DOUGALD BALLARDIE,
2 West Howard Street, Glasgow.

DISCUSSION.

The PRESIDENT, in reference to the light afforded by the new lamp, said the great beauty of the common lamp was that they had a light all round. The photometric light might be deceptive to a certain extent as was the case with all short lamps. The Davy lamp would be a very small light if it was not that the funnel was so long that the light got higher up. Having said that, before expressing his opinion, he would like to hear what the other members had to say. He suggested they should direct the discussion as to whether accidents from falls of roof were more likely to take place with Davy lamps than without them. That was beyond opinion now for they had practical tests. That being given, the next point was, was there plenty of light? Did they want more light than any of the Davy lamps in use gave? Then there was the weight, and he thought it would be well to direct attention to the real point here upon which Mr Ballardie put value, viz., the question of the gauze on the under side of the lamp being sufficient to put out the light, and also that there was no chance of the ignited gas in the lower chamber communicating with the gas outside,—he meant in the same way as a Davy lamp placed in a current. It had, as Mr Ballardie said, been found unsafe in six feet or eight feet per second. He could not say he had

fessor Abel's test, and I do not think it would be possible to get such a heat down to create that.

Mr RONALDSON—Then there is the fact that the inlet air can be shut off by means of this shutter. He can shut off the air or the explosive gas coming in there.

Mr ROBSON—And put out the fire.

The PRESIDENT—Wherein does that differ from a man putting down the flame with a picker?

Mr ROBSON—It is only another way of doing it.

Mr LOVE asked if they could put the light out by that chamber without screwing it?

Mr BALLARDIE—No; but it might be made to do so.

Mr HASTIE asked an explanation as to the experiments in the mine.

Mr BALLARDIE said the gas was in a hollow in the roof, and a Davy lamp was placed in it by the firemen. Afterwards, this lamp was placed in with the results stated.

Mr LOVE asked what would be the cost of the lamp?

Mr BALLARDIE could not exactly tell.

The PRESIDENT—It is an experimental lamp. He believed it would require to be made stronger. Mr Ballardie was simply showing the principle just now.

A MEMBER asked how heavy the lamp was?

Mr BALLARDIE—3¾ lbs., when fully trimmed to burn 22 hours.

Mr ROBSON—A Jack lamp is 3 lbs.

The discussion was adjourned till next meeting.

DISCUSSION OF MR MACCREATH'S PAPER ON THE SUCKING POWER OF THE COMMON PUMP, &c.

The PRESIDENT reminded them that the discussion on this paper was adjourned last night, to enable them to obtain some information from Mr Grant, Kilmarnock, in reference to water-works he had been erecting. The Secretary, however, had received a letter from Mr Grant stating, in the first place, that he

could not be there that night, and in the next that the subject was such he would like to give a short paper on some practical points in pumping; and he (the President) thought that was perhaps the best thing for the Institute that could be done. Mr Grant was a man of some experience in these matters, and he thought it would be better to close this discussion after hearing any remarks that the members might desire to offer.

Mr MacCreath—At last meeting Mr Drinnan asked in effect, whether in extracting the air from a pump, the driving of the bucket quickly might not give the rising water a velocity sufficient to carry it higher than that due to the proportion of the air which the dimensions of the pump were in other respects calculated to exhaust. It appears to me on consideration that the water will not so rise to any appreciable height, because the rarifaction of the air, and consequent ascent of water, is towards the end of the operation somewhat slow. Take the example referred to, where the half of the air is the limit of the exhaustion, it will be found when $\frac{2}{5}$ of the air has been pumped out that the effective part of the stroke is not more than $\frac{2}{5}$ of a foot for the 4 feet swept by the bucket, and the mean velocity of the rising water only $\frac{1}{10}$ of that of the bucket, and that without making allowance for friction or weight of valves. I have been asked by members who were present at the reading of the paper, and who had ram casings burst by their pumps getting on air, why the air drawn in did not on the down stroke act as a cushion between the ram and the water and save the shock. In such a case, it should be borne in mind that the air when drawn in is rarified probably to half an atmosphere, and it does not require even the statical pressure of an ordinary lift of pit pumps to squeeze it into the space usually left in such pumps between the ram and the casing. With a 12-in. ram and a 13-in. casing, the space between is nearly $\frac{1}{7}$ of the whole space within the casing, and the pressure due to 16 fathoms of water would probably be sufficient to compress the rarified air to one-seventh of its bulk. Fourteen fathoms pressure would be enough if the temperature of the air remained constant.

The President then declared the discussion closed, and at his request a hearty vote of thanks was accorded to the author of the paper.

NOTES ON THE PART PLAYED BY COAL DUST IN EXPLOSIONS OF FIRE-DAMP.

BY MR ARCHIBALD GARDINER.

IN these notes the subject is treated under three heads. First—The condition of a mine wherein explosions of coal dust may occur, and the various methods that have of late been put in use to prevent these explosions. Secondly—The physical properties and chemical constituents of the various kinds of coal: to assist in understanding the various combinations of the elementary gases in the formation of and ultimately contained in the pores of coal. Thirdly—Compilation of results from the most prominent experimentalists of late years, with the writer's conclusions drawn from these experiments. Some writers on this subject consider that the sudden changes of weather have an influence on explosions. This is doubtful.

CONDITION OF THE MINE.

A mine completely saturated, or thoroughly wet, lies beyond the limit of this paper. It may be said that a slightly damp mine should be excluded for the same reason; but such is not the case in the writer's opinion. Watering the roads of a dusty mine, as the streets are watered in summer, has been recommended in the public prints and elsewhere, and the use of salt water has also been suggested. A French scientific paper has recommended the distribution of sea salt over the roads in quantities of one ton to 600 yards. At first, once a week for a month, then once a month thereafter. Owing to the deliquescence of the salt the dust remains adherent to the floor like wet sand. Another paper in quoting the above suggests a less costly method, viz.—by watering with chloride of magnesium dissolved in water. To water a mine places it on the same footing as a slightly damp one. In such cases will the dust in the mine remain harmless in the event of an explosion? In considering the question, the amount of heat evolved by an explosion of fire-damp has to be taken into account. One lb. marsh gas,

i.e., 24¼ cubic feet, imparts to 1 lb. of water 23,513·4° Fah., or what is the same thing it would convert 20 lbs. of water into steam of 1178·6° Fah. This is the original heat generated by the ignition of the gas; but there is a secondary heat generated, the amount of which is difficult to compute, viz., friction in the roadways, velocity of the expanding gases, &c. It must also be borne in mind, evaporation goes on in a mine less or more from the heat evolved from workmen, lamps, horses, besides the natural heat in a mine. From these sources of heat the water of the morning will be a vapour in the evening. Again, another evil a system of watering engenders which otherwise would not exist, is the agglomerating of the dust into a semi-baked state, thereby preventing the escape of gas from the coal, and shutting up in the mine a dangerous enemy, which otherwise would be out of the mine entirely. Other evils might be adduced, such as the stability of the floor of the mine being interfered with. The same arguments may be used against the application of salt to the water, as well as magnesium chloride and water, with this additional that a new and dangerous factor is introduced, viz., chloride, magnesium, and sodium — the chemical constituents of salt and magnesium chloride. Salt contains 68% of chlorine, which is as hurtful as carbonic acid, if not more so. In the event of evaporation taking place by the excessive heat of an explosion of fire-damp, a crust or deposit of salt will be left in the dust of the mine, and may be claimed as a preventative to the uprising of the dust. That is questionable, but granting it would, the salt would be set on fire by the heat of the explosion, and the mine filled with chloride fumes. These fumes may be seen at St. Rollox Chemical Works when the retorts are being charged, or issuing in the form of a whitish yellow smoke from the chimney stalk of a brick work during the process of salt glazing. It may be judged what a mine would be like when combustion takes place with such abundance of salt in the roadways as one ton to 600 yards, when it is borne in mind that there is only a few cwt. used to salt-glaze a kiln of 30,000 to 40,000 bricks. Before leaving the consideration of this supposed preventative of watering, the following may be quoted:—"At West Stanley Colliery an explosion occurred on 19th April, 1882; 13 out of 18 men

that were in the pit at the time were killed. Mr Johnstone, manager of the colliery, stated in his evidence at the enquiry into the cause of the explosion that "the Busty was a dry seam, and the coal was of a dusty nature and liable to fly about, and to render it safer they watered it every day."

There is another source of heat which falls to be noticed, viz., spontaneous combustion. This source of heat arises from two causes: (1) The oxidation of the sulphides in the coal; (2) The oxidation of the free or disposable hydrogen and carbon to be found in the pores of the coal.

The first of these causes requires some exciting agent. Moisture furnishes this agent. Chemical action takes place, sulphuric acid being formed; consequently, great heat is generated. The second will be better stated in Dr. Percy's work on 'Fuel' thus:—

"The first equivocal sign of incipient combustion is a peculiar smell termed 'Fire Stink' by the colliers, which appears to me to be precisely similar to that which is produced by distilling coal at the lowest temperature at which decomposition commences. I came to the conclusion that such incipient decomposition had begun, and conceived that it was due to the heat developed by the oxidation of accumulated finely-divided coal, just as in the well-known case of a heap of oiled rags. It was reserved for Richiter, a foreign chemist, to substitute fact for opinion, and to demonstrate by experiments, which, in my opinion, are conclusive, that generally the spontaneous ignition of coal is due to the heat developed by atmospheric oxidation of the organic substance of coal, and not to that resulting from the oxidation of iron pyrites."

The foregoing is from undoubted high authority, and it can readily be conceived that explosions may take place of gases generated in the open spaces behind roadside buildings, in long-wall work; or in rooms not used as roads, in pillar and stall work; in dry dusty mines of bituminous coal. The dust ought to be sent to the surface, and there utilised for coke making or some other purpose. In the opinion of the writer, a superior dense coke could be made with this dust in special ovens, which would more than recoup the expense of collecting it and sending it to surface, besides obviating any chance of its taking part in an explosion.

They are classified as Lignite, semi-Bituminous, Bituminous, and Anthracite.

Each of these divisions has its own particular properties, as hardness and softness, turning out regular or irregular cubical forms when broken, or easily reduced to a fine dust. True *Lignite* has a woody character and contains much water, gives off an offensive smell in burning or when exposed to the weather. The dust of Lignite is of an inflammable nature and very light.

Anthracite.—It contains from 80 % to 90 % of carbon, the rest being water, ash, &c. The high percentage of occluded gases from so dense a structure has given rise to many theories as to the formation of this coal. As much as 24 times its own volume of gases have been drawn from the South Wales Anthracite, when heated to a temperature of boiling water. Wethered 'On the Formation of Coal' denies the agency of heat in the formation of Anthracite. He says—"In order to thoroughly comprehend the matter, let us first consider in what the difference consists between Anthracite and Bituminous coals. It is that the proportion of fixed carbon is greater in the former, with less volatile matter than is contained in the latter coals. Its decomposition depends upon the amount of oxygen and hydrogen which can unite with the carbon. The oxygen forms carbonic acid, which is one atom of carbon to two atoms oxygen; thus, for every two atoms of oxygen which pass off, there is only one of carbon, thereby increasing the proportion of the latter to the whole in what remains behind. It is a similar process with hydrogen. Marsh gas is formed, having the composition of one atom of carbon to four atoms of hydrogen. Allowing this process to go on for any length of time, a mineral deposit would result of the composition of Anthracite. If, however, oxygen and hydrogen be introduced from another source, then the proportion of carbon would be reduced, and what may be termed the fixed hydrogen and oxygen would increase in proportion to the whole, and a coal would be formed having a greater percentage of volatile constituents."

Bituminous and Semi-bituminous Coals embrace all those coals

ranging in composition from Lignite—with its 45 to 55 per cent. of fixed carbon and upwards of 40 per cent. of volatile matter, and specific gravity of 1·10—on the one hand, to Anthracite, with its 80 to 90 per cent. of fixed carbon, little or no volatile gases, and specific gravity up to 1·75 on the other. Their structure is varied, hard and brittle, soft and crumbly, and all intervening grades from hard to soft. According to the theory above advanced, and which the writer ventures to support, viz., That, by oxidation of the organic substance of the coal, the dust of Bituminous coal, when in a highly comminuted or pulverized condition, is liable to undergo oxidation in proportion to the surface exposed. It is well-known by all students of chemistry that, at the ordinary pressure of the atmosphere, oxygen and hydrogen, if mixed together, will not combine, unless a light be applied to, or an electric spark be passed through the mixture. It is also known that spongy platinum absorbs within its pores both of these gases, and, from the quantity of each of those gases it can absorb, the gases must be in a very condensed state; they combine together at the ordinary temperature of the air, and the heat developed by the union is quite sufficient to render the platinum incandescent. Fire-damp and air mixed in the proportion of 1 to 10 undergo no chemical change at temperature below red-heat; but when occluded gases in coal come in contact with the oxygen of the air, will they not combine? *i.e.*, oxygen of the air and the carbon and hydrogen in the pores of the coal combine, generate heat, and reach the igniting point. There are sufficient reasons for venturing the suggestion. Although combustion may not be set in, yet a slow process of distillation or gas making may be going slowly on, filling up some quiet nook ready for ignition. This is due to large accumulations of coal dust thrown into cundies behind stoppings, thoughtlessly put there to be out of the way.

THE RESULTS OF EXPERIMENTS WITH COAL-DUST.

In the investigations made by the late Professor Rankine, of Glasgow University, in connection with the explosion at Tradeston Flour-Mills in Glasgow, on 9th July, 1872, he shewed that, under certain conditions, organic dust was as dangerous as any

gas if approached with a light. Since that time explosions and fires in flour-mills have been easily accounted for, and provision made to prevent them.

Two years after Professor Rankine's report on the Tradeston Mills disaster, M. Vital, a French Mining Engineer, observed the apparent absence of fire-damp in the case of an explosion in Campagnac Colliery in 1874. He commenced a series of experiments on the dust of that mine, and was of opinion that the explosion was due to the firing of a shot, whereby a cloud of dust was set afloat in the workings and ignited.

Since he gave his results to the world in 1875, numerous experiments have been made—notably those of Messrs Galloway, Thomas, Professor F. Marreco, and Morison, of this country; and Messrs Le Chatelier and Mallard, in France.

From many observations made at collieries, breweries, and distilleries it appears that there must be a great quantity of dust floating, and at a high temperature, before coal-dust or organic-dust of any sort will cause an explosion. According to Galloway the proportion requires to be equal volumes of coal-dust and air with ·892 per cent. of fire-damp to render it explosive. But it would appear that this result was obtained from coal-dust of one colliery only, and it is but fair to say, it is not satisfactory, as there is, no doubt, a considerable difference in the combustibility of different samples of coal-dust, although they may agree nearly in their chemical composition. This quantity of coal-dust is much in excess of what may be expected to be afloat in a mine, unless on some special occasion, brought about by unusual commotion, such as a blown out shot, and then it would only exist for a short period. Professor Marreco and D. P. Morison experimented on these lines, their idea being, "that if two shots could be arranged and fired into the air so as to imitate more or less closely the condition under which coal-dust might, in practice, get mixed with air and might then come in contact with shot gases, it would be seen whether, under these conditions, which were probably the most trying they could have, any result could be obtained which might be fairly called an explosion." Even on the small scale that the experiments were conducted, very bright flashes and explosions were produced, which, multiplied to the scale of an air-

way or a large gallery, would yield something which would deserve the name of an "explosion proper." On the discussion on this paper it was stated that an ordinary large oil-lamp lighted had been put into the hopper where the ground coal from a disintegrator was collected, the air of which was heavily charged with coal in a finely divided state, yet no explosion took place. Another remark was—"In North Staffordshire with a coal impregnated with hydro-carbon gas, where the mine was very dry and ventilation good and no gas seen in the place, a cap on the flame of safety lamp was seen when the miners were at work. No cap was seen after the men had ceased working and the dust had settled down; yet, the observer could not say that in the course of his experience he ever knew of an explosion of coal-dust ignited by a safety lamp. The particles of coal-dust partially consumed in the flame of a lamp evolve hydro-carbons of a more complex character than marsh gas and must render the atmosphere dangerous. It has been the custom on the Continent for a number of years, in many collieries, to use covered lights for this reason. Thomas, on "Coal Mine Gases," states that he experimented with coal dust in a mixture of marsh gas with more than fourteen parts of air, but was unable to obtain any definite result, considering no satisfactory data could be got by experimenting on a small scale.

The French Fire-damp Commissioners give the following results in a decided tone:—1st, Accidents are rare, and very few are recorded, from coal-dust explosions; 2nd, When they do occur they are seldom of a serious nature, and the length of flame has never exceeded 55 yards; 3rd, Non-fiery mines have never been the scene of disastrous explosions, although the Lignite mines—the dust of which is far more inflammable than coal dust—are included in this number. They are of opinion that their experiments placed beyond doubt that fire-damp is the primary cause of explosions; and lastly, Explosions that can be traced to coal-dust are due to blown-out shots, placed on or near the level of the floor of the mine. Coal-dust that is explosive must be from a coal yielding at least 30 per cent. volatile matter on distillation. When a blown-out shot does take place, and raises up clouds of dust to a favourable point to cause an explosion,

such occasions or opportunity only exists for a remarkably short time, as the dust subsides very rapidly. This fact, taken along with the slowness of the travel or propagation of the flame, explains the reason why coal-dust explosions only extend over short distances—*i.e.*, the current of air produced by the coal-dust explosions not being strong enough to raise fresh clouds of dust up to carry the explosion along. As to the amount of fire-damp required to render coal-dust explosive, when the dust in itself is not combustible, they consider 5 per cent. too little. But when an explosive mixture of fire-damp and air is ignited, and the atmosphere of the mine charged heavily with coal-dust, the explosion is very much aggravated in consequence of the dust; besides, the after gases are of a very poisonous nature, owing to abundance of carbonic oxide in the mine from the combustion of the coal-dust. In conclusion, they state having established the fact that coal-dust only acts as an aggravating factor in cases of fire-damp explosions—only playing a minor part, and rarely ever causing an explosion.

Having in a brief manner laid before you the abstract of the results of these various experimentalists, the writer is of opinion that the following are the points which can be said to be supported by these experiments and observations as to the part played by coal-dust in explosions:—1st, All coal-dusts are explosive substances when met with in the following conditions:—In great quantities, dry, and at a high temperature—say not less than 100° Fahr. When these conditions are not met with, the most coal-dusts are unexplosive substances. This conclusion may be questioned, and the results of Professors Marreco and Morison be referred to, but it will be observed that no notice is taken of the temperature in their experiments. The charge of powder weighed 30 grains on each occasion, excepting Nos A 2, 3, and B 1, which were only 15 grains. This, at first sight, may seem trifling; but, on closer inspection, it is very material, for the charge of 15 grains to so small an area as 36 square inches is equal to a charge of $\frac{3}{4}$lbs. in an ordinary room of 68 to 70 square feet in area. Sufficient proof is given in the North of England experiments that, with the increased temperature generated by increased quantity of powder used, more dust was

rendered explosive; consequently a longer flame was found. The second point supported by these experiments is:—Coal-dust in the presence of fire-damp, although only in small quantities, is dangerous. Experimentalists are undecided as to the amount of fire-damp that will render dust explosive; but this much can be gleaned, that although an amount less than 5 per cent. be present—if the coal be of a bituminous nature—the amount of heat evolved is much increased, owing to the presence of fire-damp; consequently the temperature of the mine is increased to a point nearer to what coal-dust would become explosive in itself. Therefore, it is necessary to be ever on the watch, with a dusty mine, should any fire-damp be present. Again, the writer is of opinion that it is better to collect the dust and send it up out of the mine at once, than to throw it into buildings or elsewhere, from an economical as well as a humane point of view. An economical method of sweeping the main roads would be by a circular brush, the sweepings being filled into covered tubs. This is not a new mode, as it was in practice between thirty and forty years ago within a very few miles of this place.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING, 9th MARCH, 1883,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

Ralph Moore, Esq., President, in the Chair

Upwards of Sixty Members were present at the Meeting.

The Secretary read the minutes of the previous General and Council Meetings; they were approved of and signed by the President.

The following gentlemen were balloted for, and admitted as Ordinary Members :—

DAVID ABRAHAM, Mining Engineer, Dowlais Iron Works, Glamorgan.

HUGH BAIN, Manager, Brownrigg Colliery, by Airdrie.

WILLIAM BROWN, Manager, Newton Colliery, Newton.

ROBERT CLARK, Agent, Arniston Colliery, Gorebridge.

ARCHIBALD GRAY, Iron Works Manager, Glengarnock, Ayrshire.

WILLIAM GREEN, Manager, Galston Colliery, Galston.

LAURENCE HILL, Civil Engineer, 59 St Vincent Street, Glasgow.

WILLIAM HILLHOUSE, Manager, Maxwood Colliery, Galston.

ALEXANDER LAWRIE, Manager, Hayside Colliery, Kilmarnock.

JOHN M'GOWAN, Colliery Manager, Gilmour House, Liberton, Edinburgh.

JAMES MOFFAT, Coal Salesman, Cadzow Colliery, Hamilton.

JAMES MUIR, Assistant Colliery Manager, Academy Place, Wishaw.

JOHN C. MUIR, Manager, Wishaw Collieries, Wishaw.

GEORGE NEILSON, Ironmaster, Summerlee, Coatbridge.

JOHN NEILSON, Engineer, Summerlee, Coatbridge.

THOMAS RIGG, Colliery Manager, Doura, by Kilwinning.

JOHN ROBISON, Manager, Springhill and Cauldhame Collieries, Kilmarnock.

GEORGE RUSSELL, Manager, Summerlee Iron Works, Coatbridge.

ROBERT STEVENSON, C.E., Colliery Manager, Lochgelly Iron Works, Fife.

ROBERT STEWART, Manager, Legbrannock Colliery, Holytown.

JAMES F. WALDIE, Commercial Manager, Legbrannock Colliery, Holytown.

WILLIAM WALKER, Agent, 66 Waterloo Street, Glasgow.

WILLIAM WILSON, Fireclay Manufacturer, Walmer House, Dunfermline.

Other three gentlemen were then nominated for election, and will be balloted for at the first meeting.

In accordance with the Rules, seventeen gentlemen were nominated as office-bearers for the ensuing session.

The following alterations of the Rules were proposed.

Mr JAMES S. DIXON proposed that Rule I, Section VI, be altered to read as follows:—

"There shall be six ordinary General Meetings in each year, to be held in Hamilton—unless elsewhere arranged for by the Council—on the second Thursday of every second month. The Annual General Meeting to be held in the month of April."

Mr DUNDAS SIMPSON proposed that, in future, the meetings should be held in Glasgow.

As required by the Rules, the proposed amendments were delayed for discussion at the Annual Meeting.

DISCUSSION ON MR BALLARDIE'S SAFETY LAMP.

The PRESIDENT, in introducing this discussion, hoped the Council would authorise Mr Ballardie to make a new set of drawings, giving a section of the lamp, and a detailed drawing of every part of it separately.

Mr LOVE asked if it was the case that the gas burned in the lower chamber after the light was out.

Mr BALLARDIE—If there is a sufficient body it will, in the same way as in a gas stove, but the cover is arranged to shut it off instantly.

The PRESIDENT pointed out that there was a sort of shutter which, they would see, opened or shut off the air at will.

Mr ANDERSON—As I understood, it is the explosion in the lower chamber which extinguishes the light: would the reduction of the size of it have any effect on the lamp?

Mr BALLARDIE—It might be made a little less, not much; a fourth less capacity would extinguish the light.

The PRESIDENT—But supposing I only meant to send in sufficient air for combustion, it might be much less?

Mr BALLARDIE—Certainly.

Mr DRINNAN understood that there were some parties in the Hamilton district who had been experimenting with the lamp since last meeting, and he asked if any of these were present and able to say how the lamp would work in actual practice.

The SECRETARY said that Mr Hastie, of Greenfield, had been making some experiments on the lamp, but he was not present at the meeting.

The PRESIDENT said that what occurred to him was—after the meeting had thoroughly discussed the lamp they ought to appoint a committee to report upon it and take into consideration the points mentioned in the course of the discussion.

Mr ANDERSON, referring to page 295, as to the quantity of light given by the principal lamps, said the Teale Protector Lamp was given at ·12, and the Williamson Lamp at ·35. There was a committee appointed recently by the Institute to go through a series of experiments in regard to the quantity of light given by the different lamps. The figures given in Mr Ballardie's table did not accord with what the committee found, and he only hoped that Mr Ballardie's lamp was not as much in excess of what it should be, as the Teale Protector was less than it should be. The Teale Protector Lamp, he thought, gave more than ·12, a light not up to the light of the Davy. He for one would be very hard to convince that that was the case, for he thought that one Teale Protector Lamp was fully better than four Davys as to the quantity of light they gave out. They were working with several hundreds of them at Auchinraith, so that it was not a matter of opinion, without being fortified by facts.

Mr BALLARDIE said he had been made aware lately that the figure he had put down for the Teale Protector was rather under the mark. Professor Abel had told him that day. His authority was a paper by Dr Wallace, Glasgow, read before the Philosophical Society. He had no opportunity of testing the question.

The SECRETARY—How long is it since Dr Wallace's paper was read?

Mr BALLARDIE—It was in 1878 or 1880.

The PRESIDENT recollected that this was the case, for he made the experiments along with Dr Wallace, and the result at that time was as stated, but he believed it was rather low.

Mr ANDERSON—As regarded this Teale's Lamp, thought it must have been tested under very unfavourable circumstances.

Mr DIXON said, so far as he saw, the lamp might be a very good one, and if it gave anything like the light given—1·27 candles—it was a good one in that respect. He thought they should follow up the President's suggestion, and allow the Council to appoint a committee to put the thing to a practical test.

Mr JOHNSTONE said he had read the paper, and considered the photometric value of the light very high. He would be very willing to act with any members in going to Anderson's University (where he had the privilege of using the photometer) to test the lamp.

The PRESIDENT, in closing the discussion, asked the meeting to give a vote of thanks to Mr Ballardie for giving them this paper, and for the trouble he had taken in showing them his lamp.

This was cordially agreed to.

DISCUSSION OF MR GARDINER'S PAPER

ON THE PART PLAYED BY COAL DUST IN EXPLOSIONS OF FIRE-DAMP.

The PRESIDENT stated Mr Gardiner had been very industrious in gathering the opinions of other people, and had given altogether a very readable paper. He asked Mr Gardiner if he had anything to add to the paper.

Mr GARDINER drew attention to the manner in which his paper had been curtailed by the Council, and expressed a wish to read a supplementary paper.

Mr JOHNSTONE had studied the subject of coal-dust for a number of years previous to the explosion in the Tradeston Mills in Glasgow. A friend of his had drawn his attention to the explosive nature of flour-dust. He had himself experimented on and exploded flour-dust. He recommended that coal-dust should be laid with water.

The PRESIDENT said the great question was what to do with the fine dust. Mr Gardiner had proposed a mode of sweeping it up by a circular brush.

Mr SMART said that at p. 306 Mr Gardiner referred to spontaneous combustion as being one of the dangers to be encountered. He asked Mr Gardiner to inform them how the experiments referred to were gone about, proving that the spontaneous combustion resulted not from the oxidation of the sulphides but from the oxidation of the fine hydrogen in the coal. They found that there were many and varied circumstances which caused spontaneous combustion. They had it in the mine certainly very frequently, and they had it in coal and dross bings and in ships. He thought with him that the better way to get rid of the dust of the mine was to sweep the house.

Mr GARDINER said that Dr. Percy admitted that he based his opinion upon observations of the South Staffordshire 10 yard coal in which there was no sulphur. It might be recollected that when Mr Calderwood read his paper on the Staffordshire coal, he (Mr Gardiner) put a number of queries on this point; and he found that that was where Dr. Percy formed his opinion, although the German chemist wrought out the experiment in the laboratory.

Mr SMART—Can you account for it taking fire in a bing, and while lying in a very small quantity?

Mr GARDINER—Yes, for I have seen a bing 12 inches deep take fire. In this case it was owing to the oxidation of the sulphides in the coal. I had to contend with three or four fires underground when in India from that source.

Mr JOHNSTONE asked Mr Gardiner's experience of free hydrogen. Supposing it in the coal, and that it had escaped, which they

might well suppose when coal under a pressure of several tons to the square inch, from the large load of surface upon it, was brought to the surface,—was there not a chemical change produced sufficient to fire the free hydrogen sent forth in sufficient force that if a light were put to it it would fire? This was a very important question, because it related to coal in steamships. What was the cause of combustion? Was it the pyrites and foreign matters, or was it merely to the carbons and hydrogen that the chemical change was due? Then it was for shippers to look out for a coal free of all risks from fire.

Mr GARDINER said he referred to free hydrogen. It was a question as to what form it existed in the coal field proper. It was allowed by some chemists that it was a solid, and it was by the exposure to the air that it formed a gas, or relieved from the pressure of the over-lying strata.

The PRESIDENT—In the case you refer to in India were there any pyrites in the coal?

Mr GARDINER—Yes; the coal was full of pyrites which caused the fires. He had not seen any case of spontaneous combustion himself, but they had seen them from papers.

The PRESIDENT—Where did you see them?

Mr GARDINER—In the Transactions of the Institute and in Dr. Percy's book.

The PRESIDENT—There are pyrites in the Staffordshire coal.

Mr DRINNAN said Mr Gardiner had been dealing with what they might call a very dark subject, and it seemed to him after reading the paper he had only succeeded in making the darkness a little more visible. On that account he intended to have had something to say, but after Mr Gardiner's statement he thought that he would defer his criticism until they got the supplementary paper and knew what were his real opinions.

The SECRETARY explained that a proof of his paper had been sent to Mr Gardiner for correction, but he had returned it without alteration or comment.

The meeting then adjourned to the Choral Hall.

IS BLASTING GELATINE, AS HITHERTO MANUFACTURED, A SAFE EXPLOSIVE?

BY MR JOHN DRINNAN, AIRDRIE.

THIS question is forced upon us by the recent action of the Government in issuing orders which practically have had the effect of stopping the manufacture of an explosive which I hope to be able to show is recognised by all those who have used it as one of the most efficient, if not the most efficient hitherto known.

To assist members in forming an opinion as to whether the Government authorities were right or wrong in the action they have taken, it will be necessary for me to refer to the circumstances which prompted that action; but in doing this I will be as brief as is consistent with fairness to all the parties concerned.

In October of last year, Colonel Majendie, Her Majesty's Chief Inspector under the Explosives Act, instituted a prosecution against one Robert Hamilton, keeper of a magazine at Pumpherston Mains, parish of Mid Calder, and the complaint as set forth, though it also involved an inquiry into the condition of the magazine, was really directed against the condition of the blasting gelatine which was there kept. The purposes of this paper do not require that we should deal with the argument on the first charge, and it will simplify the case, without at all prejudicing the prosecution, if we deal only with the second charge, which was that the defender, already named, being licensed to keep blasting gelatine of a quality which would not be liable to liquefaction or exudation, did contrary to the terms of his license keep gelatine that was liable to, and actually did, liquefy, as also that it did exude, that is, that separation of its ingredients took place under ordinary condition of temperature and use. The action, though nominally directed against the keeper of the magazine, was really directed against Nobel's Explosives Company, and the company at once recognised this by employing counsel and putting pleas on record to the effect that the gelatine as manufactured by them was not, under ordinary conditions of temperature and use, liable to liquefaction or exudation. The case was heard before Sheriff Rutherford of the Lothians, at the

instance of the Procurator Fiscal, and Nobel's Company were defended by Mr J. P. B. Robertson, instructed by several eminent Glasgow and Edinburgh lawyers.

The first witness called was Colonel Majendie; but as his evidence had reference mainly to the condition of the magazine, it is not necessary to do more than take note of that part of his evidence wherein he states that for considerably more than a year a discussion had been going on between himself and Nobel's Company as to a proper test for purity in the explosive herein dealt with. Dr Dupré, chemical adviser of the Home Office on these points, had reported adversely on some of the samples submitted to him, and Nobel's Co. objected that the tests to which the samples were subjected were unfair. The result of that correspondence had been a reference to Professor Abel and Dr Dupré, for the purpose of determining a satisfactory test.

Dr Dupré, the main witness for the prosecution, described blasting gelatine as a chemical compound of collodion or nitro-cotton and nitro-glycerine, in the proportion of not less than 7 per cent. of the former to 93 per cent. of the latter, the union being effected at a slightly elevated temperature, and in cooling, the mass sets or gelatinises, forming a semi-solid substance, which has received the name of Blasting Gelatine. Nitro-glycerine at the ordinary temperature is a liquid, nitro-cotton being a solid; and Dr Dupré asserted, what I believe is not disputed, that gelatine, when well made, will not separate into the liquid, and solid parts, at least, not at ordinary temperature. Good blasting gelatine was further described by him as a *very stiff* semi-solid mass, which should not become soft or fluid at any temperature below 100° F., and in proof of this, he stated he had had it at a temperature of not less than 150° or 160° F.

Liquefaction, he described as the whole mass becoming soft without any appreciable separation of the constituents, and exudation as a separation into a solid and a liquid.

The cartridge taken by Colonel Majendie from the magazine already referred to, was then described by Dr Dupré as a soft mass which showed signs of exudation before he had done anything to it; that is to say, there was a small portion of liquid which had separated from the semi-solid mass, and this he con-

sidered a bad sign, as blasting gelatine, when well made, should stand repeated changes of temperature without change of character; but the gelatine in question when submitted by him to a process of freezing and thawing, showed unmistakeable signs of liquefaction and exudation, and the dangerous condition of things resulting from this exudation he described as due to the highly explosive character of the liquid which separated, for though he would not go the length of saying that it was pure nitro-glycerine, it was equally dangerous, because of its sensitiveness to percussion.

In the foregoing you have what I consider the salient points in Dr Dupré's evidence, which closed the case for the prosecution.

For the defence there were examined—James Dewar, Professor of Chemistry at Cambridge, Vice-President of the Chemical Society, and Professor of Chemistry at the Royal Institution, London; Robert Tatlock, Analytical Chemist, and Chemist to the City of Glasgow; and both these gentlemen claiming to have a practical knowledge of the explosive in question, from having been days and weeks together witnesses of its manufacture at Ardeer Works, gave evidence as to the unquestionable purity of the materials used, and the absence of any defects in its composition. The tests to which it was submitted before leaving the magazine, they also described as being very severe; but neither of them had ever seen any traces of exudation, even when samples of varied character had been exposed for months.

They also maintained that the viscosity or softness which had roused Dr Dupré's ire was one of the merits of this explosive, making it not only safer, but more powerful as an explosive; and as affording proof of this, they stated that when used in its viscous or soft state, the whole of the material would explode; but if used when in a non-viscous or hard state, some of the material would remain unexploded, and being scattered about, might explode when not desirable. In proof of the safety of blasting gelatine, as compared with dynamite, Professor Dewar also said that if you put half a dozen cartridges of dynamite side by side with half a dozen cartridges of blasting gelatine, and, standing at a safe disance, fire a rifle bullet into them, the blasting gelatine may be dispersed and left unexploded, but only in very exceptional cir-

cumstances would this happen with dynamite. Dr Dupré's tests were also objected to as being too severe, and not such as the explosive could by any probability be subjected to in ordinary use in this country. Both of the gentlemen already named also concurred in saying that blasting gelatine being a chemical compound, would not resolve itself into its original ingredients unless chemical action again took place.

The Procurator-Fiscal in his address for the prosecution submitted that what they had sought to prove was not a chemical separation, but a physical separation; and this he held to be established, as also the liquefaction; and with regard to the test maintained that the different temperatures to which the sample cartridge had been subjected were quite compatible with experience even in this country.

Mr J. P. B. Robertson, in his address for the defence, contended at the outset that even though he should fail in proving that the gelatine in question had not been liquified or that exudation had not taken place, though he hoped to prove it, he would still hold that the mere finding of one bad cartridge in a quantity would not amount to such an infringement of the license as was contemplated by the words "keeping or permitting to be kept." He then dealt with the question of liquefaction, and disposed of it by quoting Dr Dupré's own words, which were to the effect that what he saw did not exactly amount to liquefaction. There remained then only the question of exudation to be dealt with, which by the terms of the libel he (Mr Robertson) held to mean separation of the ingredients, and this he submitted could not be held as proved, unless it was established that what had been chemically combined had resolved itself into its original ingredients—that is, that the nitro-cotton had become separated from the nitro-glycerine. That this had not been proved Mr Robertson maintained was clear from what Dr Dupré had admitted in cross-examination; which was in effect that the quantity which had exuded was so small that he could not quantitatively analyse it. The assertion, then, that what had exuded was nearly pure nitro-glycerine, Mr Robertson contended was merely matter of conjecture, and should not be received as evidence.

Sheriff Rutherford in giving judgment did not think it necessary to deal with the question of liquefaction or exudation, though he expressed a decided opinion that the tests to which the cartridge had been submitted were unduly severe; and that it exceeded the bounds of reasonable probability to speak of the conditions of ordinary temperature and use as being a temperature of 14° F for 24 hours, and for the next 24 hours a temperature of 80° F. The conditions were not such as would probably occur in this country. Independently of this, however, he considered there were two defects which were fatal to the case for the prosecution; one was the alternative plea advanced by Mr Robertson that one bad cartridge in a quantity would not amount to "keeping" or "causing to be kept," and the other defect was that there was no evidence to show what had been done with the cartridge from the 17th May, when it was taken from the magazine, to the end of the month when it was placed in Dr Dupré's hands. He therefore held the first count not proved, and for other reasons, immaterial to the purpose of this paper, acquitted defendant on the second count also.

In somewhat narrow compass I have endeavoured to present what appears to me as the main facts and arguments in the case, and it is scarcely necessary that I should extend the paper further than to say that having learned from some of our workmen who had been using it, and who greatly preferred it to dynamite, that they could no longer obtain it, I made inquiry, and learned from an agent of Nobel's Co. that immediately after decision of the case to which the foregoing refers, a communication was received from the Government by Nobel's Co., the effect of which was, that they were compelled to abandon the manufacture of the gelatine until the restrictive conditions were made such as it would be possible to comply with.

From inquiries amongst workmen who have used it, and from having myself seen some proofs of its power as an explosive, I have been led to conclude that it is not only cheaper than dynamite, but it is more powerful and always in the right condition for use; while dynamite has frequently to be carried about on the person, or otherwise gradually heated, in order to fit it for use. As compared with powder, gelatine can be used with great advan-

tage where powder could not be effectively applied, such as under water, or in cases of short bore-holes where it is essential that the force of the explosive be expended as near the inner end of the hole as possible.

With regard to safety in handling, it is beyond all question much safer than powder, and in proof of this it is only necessary to say that a cartridge of it put upon the fire would simmer away without exploding.

When two months ago the matter was brought before the Institute I stated that the subject was worthy of their consideration, as the use of the substance might enable work to be done in mines with less cost than was possible with other known explosives; and I know now that this opinion is not confined to myself, for already Members of Parliament have been approached by letters and deputations, and I understand that direct remonstrances have also been addressed to the Home Secretary; and I trust that this Institute will not be behind hand in requesting the Government to cause such inquiries to be made as will ensure that no needless restrictions are imposed on the manufacture of what is generally conceded to be a valuable explosive.

ON ELECTRIC LIGHTING.

By ANDREW JAMIESON, Member; A.M. Inst. C.E., F.R.S.E., &c., Principal, College of Science and Arts Glasgow.*

THE subject of electric lighting has lately received a large amount of attention from many of our most scientific and practical men, public interest has been greatly awakened regarding it, and the patent office has been inundated with specifications and applications all more or less proposing to give us perfect electric lighting. Numerous companies have been formed, with large subscribed,

* Principal Jamieson, in the Free Public Lecture which he delivered on Friday, the 9th March, at the request of The Mining Institute of Scotland, suited his remarks and experiments to the general audience, but he has sent the following technical paper on Electric Lighting, as being more adapted for publication in the Transactions of the Institute.

and still larger nominal capital, with a view, in some instances, only to sell patents and patent-rights; in others, with the more honourable and honest purpose of making and installing their appliances—each one claiming its speciality or system to be the best either as a whole or in some particular feature.

Our leading scientific and engineering journals have, of late, been full of descriptions of this or that dynamo and electric lamp, or of some special installation or electrical exhibition, using terms and electrical phraseology which, to some, must have appeared new and difficult to understand.

There is at the present moment scarcely a town in the kingdom which has not had a trial of the electric light, and whose authorities are not worrying themselves as to whether they shall or shall not seek for a "Provisional Order," and thus have the right, under the Board of Trade, of supplying their inhabitants with "the light of the future."

Periodically this society has had laid before it by the Secretary full and interesting details of how the Swan incandescent lamps are doing at Earnock Colliery. These reports are most encouraging, and may possibly induce some of you to try electric lighting at your works.†

In this paper I shall confine myself more particularly to arc lighting and the various appliances requisite for working the same —having previously given you a description of the Swan incandescent lamp (see Vol. III., page 145)—as I believe arc lighting will be found most suitable for your surface works and larger workshops and railway approaches.

PRACTICAL ELECTRICAL UNITS OF MEASUREMENT.

In the first place, I shall define the several units used in measuring currents in connection with electric lighting. The practical electrical units of measurements now universally adopted by all electricians, were finally determined upon at the International Congress of Electricians, Paris, 1881, and the British Association, 1882.

Since electricity, by whatever means generated, is the result of

† See Vol III., pages 145 and 277, for Report on Electric Lighting at Earnock Colliery.

the expenditure of energy (mechanical energy as a rule, in the case of electric lighting), and, as the measurement of energy involves *space*, *matter*, and *time*, the three fundamental units adopted were the *centimetre* for length, *gramme* for mass, and *second* for time, which is termed the centimetre, gramme, second system, or shortly, the C.G.S. system; and upon these fundamental units all the practical electrical units of measurement are based.

ANALOGY BETWEEN WATER AND ELECTRICITY.

An electric current may, for all practical purposes, be considered analogous to a fluid, under conditions somewhat similar to those by which water flows along a pipe.

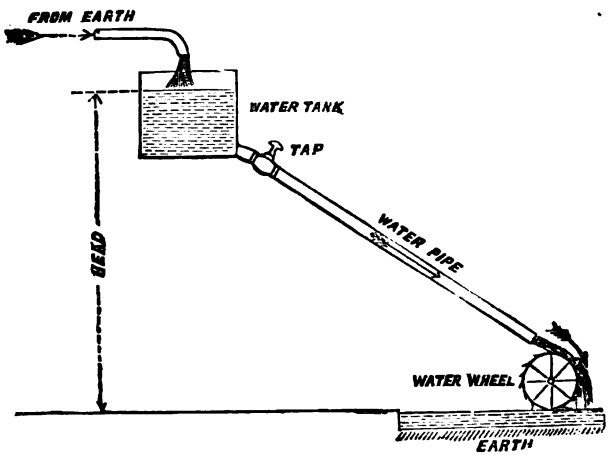


FIG. 1.

1.—*Electromotive force compared to head or pressure.*—The difference of level or pressure, due to gravity, between the top and bottom of the water pipe (Fig. 1), in other words, the "*head*," causes the flow of water along the pipe, while the difference of potential or electrical pressure between the ends of the copper wire (Fig. 2), in other words, the *electromotive force*, as it is termed, causes the flow of electricity along the wire. The potential, or pressure, in both cases determines the power of doing work, as illustrated by the water now flowing from the elevated pail along

the pipe and driving the small water-wheel on the platform, and by the voltaic battery generating electricity now flowing along the copper wire and driving the small dynamo-electric engine, also on the platform.

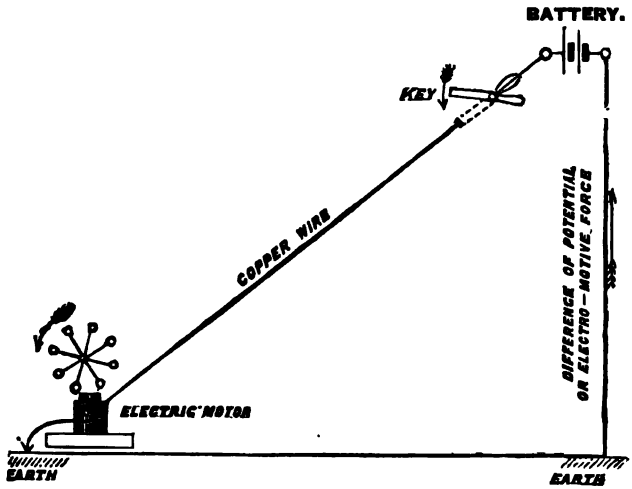


FIG 2.

2.—*Electric resistance compared to friction.*—The *friction* generated between the running water and the inside of the pipe offers a certain amount of resistance to the flow of the water, and may be considered so far analogous to the *resistance* offered by the metallic conductor to the flow of the electricity along it.

3.—*Strength of electric current compared to flow of water.*—The flow of the water along the water pipe, and the strength of the electric-current along the conducting wire, are in each case determined by the pressure overcoming the resistance.

4.—*The quantity of electricity compared with the volume of discharge or volume of flow of the water* is in each case determined by the current passed in a second.

5.—*Power.*—In order to estimate the power of the current developed in each case, we have simply to multiply the total pressure by the current passed per second.

EXACT DEFINITIONS OF PRACTICAL ELECTRICAL UNITS.

1.—*Electromotive force* = (E).—*The Volt* is equal to 10^8 C.G.S* units of electromotive force, or about 8 per cent. less than the E.M.F. of a standard Daniell's cell. Electromotive force is equivalent to the differenee of potential between two points.

2.—*Resistance* = (R).—*The Ohm* is equal to 10^9 C.G.S.* units of resistance. It is equal to the resistance of a column of pure mercury 1·0624 metres long, of a square millimetre section, at the temperature of zero centigrade; or roughly, the resistance offered by 240 feet of pure copper wire, No. 18, B.W.G. ($\frac{1}{20}$ inch, or 1·274 millimetres in diameter), at 60° Fahr., is equal to one Ohm. Resistance of copper increases with the temperature by about 0·21 per cent. per degree Fahr. Resistance varies directly as the length, and inversely as the sectional area of the conductor.

3.—*Current* = (C).—*The Ampère* is equal to 10^{-1} C.G.S.* units of current. It is the current produced by a volt through an Ohm.

Ohm's law...Current $= \frac{\text{Electromotive force}}{\text{Resistance.}}$, or $C = \frac{E}{R}$.

4.—*Quantity* = (Q).—*The Coulomb* is equal to 10^{-1} C.G.S.* units of quantity. It is the quantity of electricity given by an Ampère in a second.

5.—*Power* = (P).—*The Watt* is equal to 10^7 C.G.S.* units of power. It is the power conveyed by a current of an Ampère through a conductor whose ends differ in potential by a volt: or, in other words, the rate of doing work when an Ampère passes through an Ohm, and is equal to 10^7 ergs ($\frac{1}{746}$ of a horse-power).

$\therefore E \times C =$ Watts, and $\frac{E \times C}{746}$ = horse-power = 33,000 ft. lbs. per minute.

MOTIVE-POWER FOR DRIVING DYNAMOS.

Before describing the dynamo, or generator of electricity, I shall just say a word or two about the most suitable machines for producing the mechanical power which has to be converted into electrical energy by the former.

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* Electro-magnetic system. For the other units see Rankine's Rules and Tables, sixth edition; also, Units and Physical Constants, page 25, by Prof. Everett. The C.G.S. unit of work is called the *erg*, and there are 746×10^7 ergs in a horse-power since one foot lb. $= 1{\cdot}356 \times 10^7$ ergs, and one horse-power = 550 ft. lbs. per second $\therefore 1{\cdot}356 \times 550 = 746$.

First, we have the steam-engine; second, the gas-engine; third, the water-wheel or turbine; fourth, the wind-mill; and a fifth has been proposed, but not yet put into practice, viz., a machine for utilising the rise and fall of the tides.

Of all these, the most suitable and, at the present time, the most popular, is the steam-engine. Whatever kind of machine is adopted, it is absolutely necessary that so long as the power developed by it is applied to driving a dynamo, in direct circuit with the electric lamps, the motion should be as uniform as possible, in order to insure a steady current or electromotive force. For this purpose, in the case of the steam-engine, it should be fitted with a sensitive and efficient governor, and it should be capable of easily furnishing the necessary power without in any way overstraining any of its parts, and be constructed of the very best materials in the best possible manner, so as to minimise the chance of a break-down. In the case of workshops, where there is an ample reserve of power developed by the shop engine, and the demand upon its energy does not alter very rapidly, it has been found suitable, in many instances, to drive the dynamo by means of the same; but this should not be attempted before carefully testing and considering well the capabilities of the engine.

The demand for electric lighting has necessitated a special class of engines for this work, and several well-known makers, notably Messrs Marshall & Sons, and Messrs Tangye Brothers, have devoted much attention to this subject. The driving connection between the engine and the dynamo is usually carried out by means of belting either direct from the fly-wheel to the dynamo pulley, or by the intervention of a counter-shaft.

It is only in the case of steamships, or where the space is limited, that the motion is communicated direct from the engine shaft to the dynamo, without the intervention of belting or gearing, and in such cases the engine must be run at a very high speed, or the dynamo so arranged as to work at an abnormally slow rate.*

* As examples, we have the electric lighting on board the s.s. *Servia* by means of Swan lamps, where a Brotherhood three-cylinder engine, running at about 600 revolutions per minute, drives direct Siemens' exciter and alternate current dynamos; and the s.s. *Waihora*, just completed this week by Messrs Denny, of Dumbarton, and fitted through-

Gas-engines are becoming more popular, and, by using a fly-wheel on the dynamo shaft, with long slack belting to counteract the effect of their somewhat irregular motion, they are, in many instances, found very serviceable. Sir William Thomson has adopted a 6-horse-power Clerk's gas-engine at his laboratory, and Professor Blyth, at Anderson's College, an 8-horse-power one, apparently with good effect; and, at the lecture, we used the Otto engine belonging to the *Advertiser* Office, to drive the Brush machine.

Water-power has, as yet, been but sparingly employed, either through the intervention of water-wheels or turbines, probably from the fact that where the electric light is in greatest demand, water is not available; but there cannot be much doubt that, as the mill-owners, whose works are supplied with plenty of water-power, begin to realise the advantages of this form of artificial light, water power will be greatly taken advantage of; and, from the ease with which it can be manipulated, it will be found quite as efficient as the best steam-engine, and will certainly prove less costly.

Wind-mills and tidal machines are out of the question until that much-required desideratum, viz., the storage of electricity, can be economically effected.

DYNAMOS.

We now come to the Dynamo, or producer of electricity, for feeding electric lamps.

Gramme dynamo.—To illustrate the general principle upon which this machine depends, your attention is called to Fig. 3 and the

INDEX OF PARTS,

where S represents spindle carrying

A, A,	armature revolving between
N, S,	the north and south seeking poles of

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out upon Edison's system with 150 incandescent lamps, the dynamo being driven direct by a three-cylinder Brotherhood engine running at 500 revolutions per minute; Alley & M'Lellan, of Glasgow, also make a Westinghouse engine specially for driving dynamo machines.

M, M, M, M, the electro-magnets, around the iron cores of which, the wire from

T + the + terminal of armature is wound as shown until it joins

C + the carbon + or upper carbon of the arc lamp,

T — the — terminal of armature being joined to

C — the carbon — or lower carbon of the arc lamp;

B_1, B_2, the brushes which collect the currents from

C, the commutator, the metallic parts of which are soldered to the nearest points of the coil of wire which forms the armature.

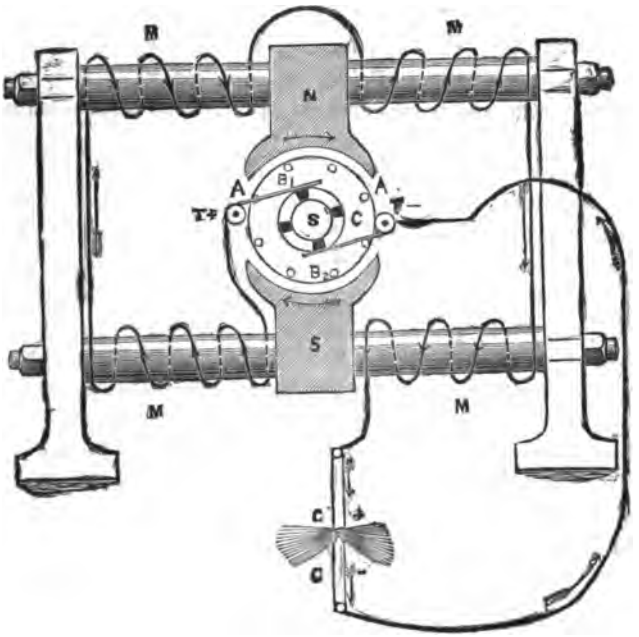


FIG. 8.—GRAMME DYNAMO.

There being always some residual magnetism in the pole-pieces, N, S, and iron cores (after having once been magnetised), there

exists a weak magnetic field between N and S, and the lines of force pass through the armature, A, A, and its iron core, at right angles to the copper wire coiled round the same. Consequently, upon revolving the armature, A, A, its copper wire coil cuts these lines of force at right angles; a current is thus generated which is led off by the brushes in the direction shown by the arrows, still further increasing the magnetism of N and S, which, in turn, reacts on the armature core and coil until such a speed is attained that the electricity generated and flowing round M, M, M, M, completely saturates the iron cores and pole-pieces with magnetism. Any further increase in speed will cause unnecessary heating of the electro-magnet coils, owing to the current passing through them being in excess of that required to saturate the cores and poles.*

Brush dynamo.—In the Brush machine the armature coils (A C) are wound upon an annular soft iron core (I C) (see Figs. 4 and 5) as shown, and being revolved in a most advantageous manner, as close as practicable to the poles of the electro-magnets, great electrical energy (E × C) is obtained for a given speed. A reduction of the total resistance of the armature coils is caused by cutting out of circuit two of them when in the least effective position. The commutator C, and its brushes B_1, B_2, B_3, and B_4 are so placed upon the shaft, outside of the main bearings, that they can be easily got at for cleaning and repair, and are therefore more easily kept in good working order. The capability of generating currents of high electromotive force, with a mean current strength of 10 Ampères, so that any number of lamps, from 1 to 40, may be worked in one circuit in series, and the comparatively low speed at which the larger machines are driven (viz., 750 revolutions per minute for a 16-light machine) are all advantages claimed for this machine.

The Brush system has been constantly at work at the well-

* An A Gramme machine belonging to the College of Science and Arts, with its different parts specially painted to illustrate (fig. 3) and make apparent their uses, was exhibited and explained to the meeting. It was shown at work driven by means of a large wooden wheel, worked by two of Mr Jamieson's pupils. By means of it sufficient electricity was generated to keep a Swan's lamp glowing at 5 candles, and to magnetise an electro-magnet, keeping a 56-lb. weight attracted to its poles.

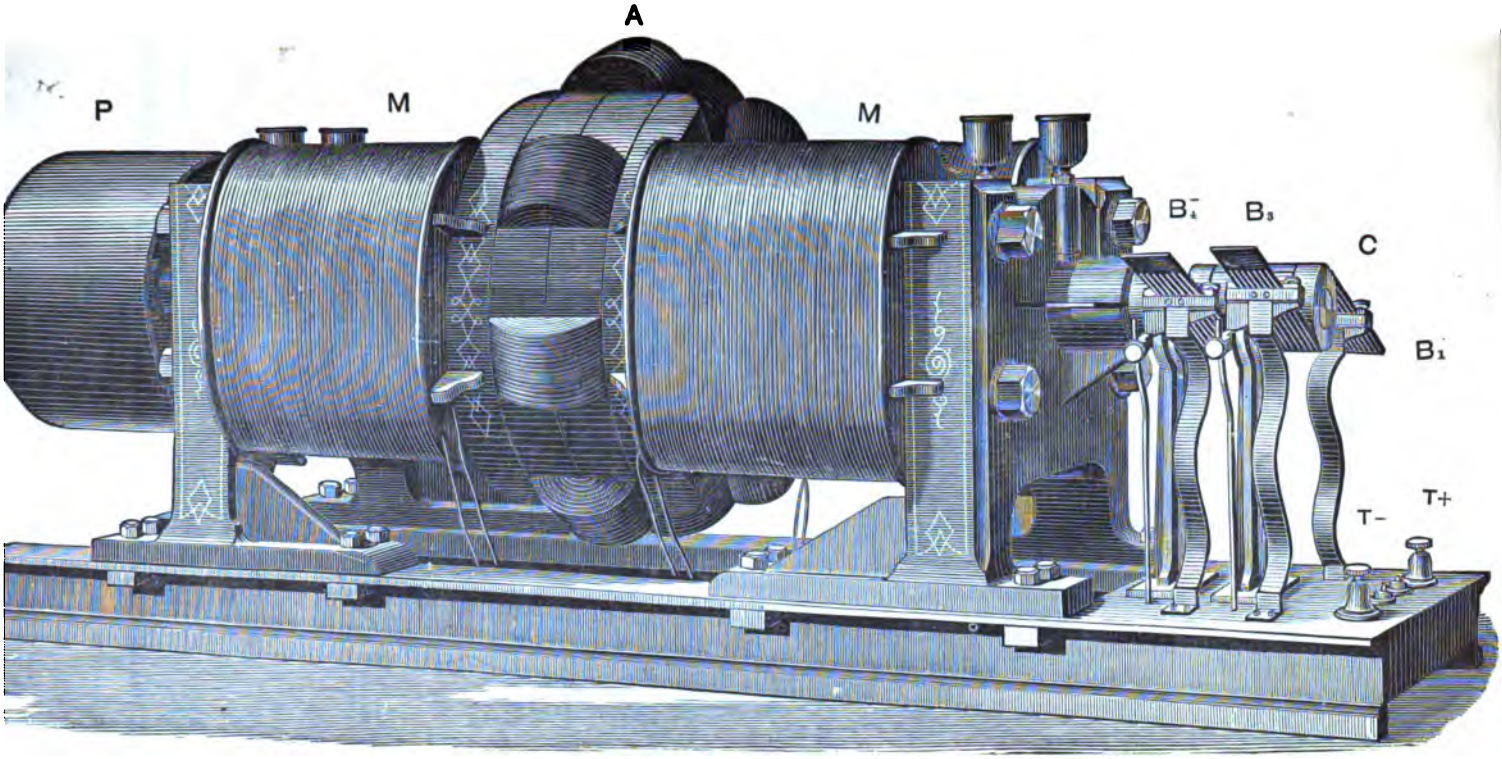


FIG. 4.—THE BRUSH DYNAMO MACHINE.

known engineering works of Messrs Mirrlees & Watson, and Messrs Robert Napier & Sons for two years, where I find it has

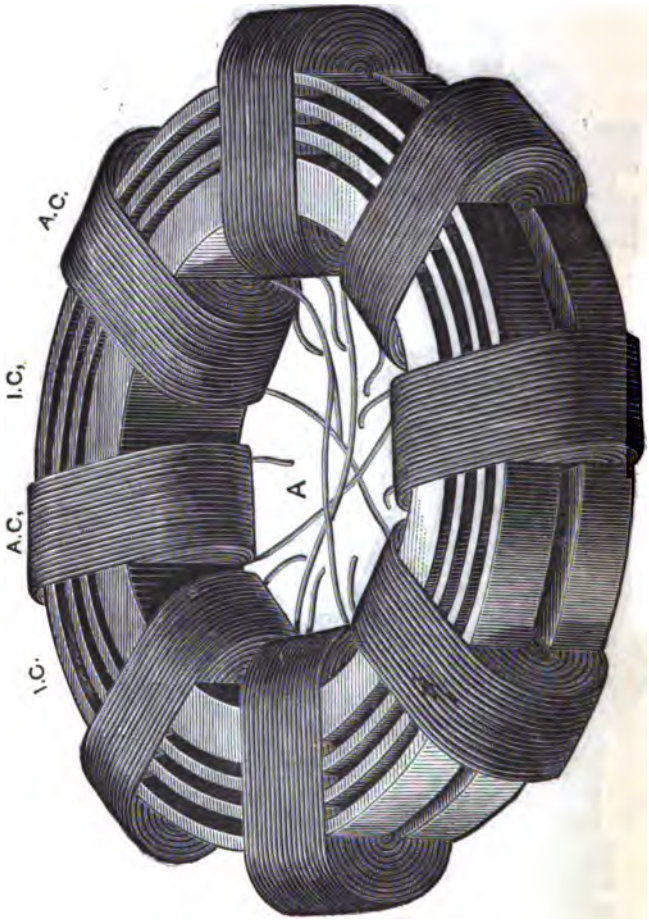


FIG. 5.—BOBBINS OF ARMATURE OF BRUSH DYNAMO.

given great satisfaction, and it has lately been installed in Aberdeen and Dundee for street lighting.

The connections of the Brush machine have hitherto been considered rather a mystery, often misconstrued from inaccurate

or incomplete diagrams hitherto given; but I hope the theoretical diagram (see Fig. 6), along with the following

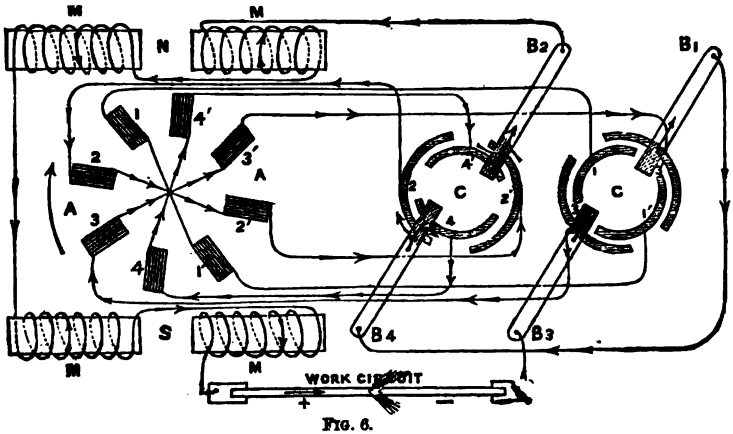


FIG. 6.

description, will make them clear to you.* The armature coils, A, A, and commutator parts, C, C, are shown in the diagram at right angles to their position in the machine, with a view to facilitate tracing the connections. The opposite coils, whose inner ends are connected together, are numbered 1, 1′; 2, 2′; 3, 3′; and 4, 4′; while the opposite plates on the commutator to which the coils are respectively connected are similarly marked. Starting from armature coils 3, 3′; and following the direction of the arrows which indicate direction of current, we come to commutator plate 3′ to brush B_1, then to brush B_4, where the current splits at plates 2 and 4; by 2 to coils 2, 2′ to plate 2′ and by 4 to coils 4, 4′ to plate 4′ where brush B_2 unites the currents again and leads them to the electromagnets, M, M, M, M, through which it passes to the + carbon or work circuit across the arc where light is produced, and along the — carbon to brush B_3, commutator plate 3, back to armature coils 3, 3′, thus completing the circuit. It will be seen that each pair of coils as they come into the position 1, 1′ are cut out of circuit, thus reducing the armature resistance mentioned before.

* I am indebted to Mr Beckinsale, manager of the Scottish Brush Coy., for assistance in getting out Diagram Fig. 6, and deciphering the connections as shown.

The Crompton-Bürgin Dynamo is a very practical and useful modification of the Gramme dynamo. It is constructed either

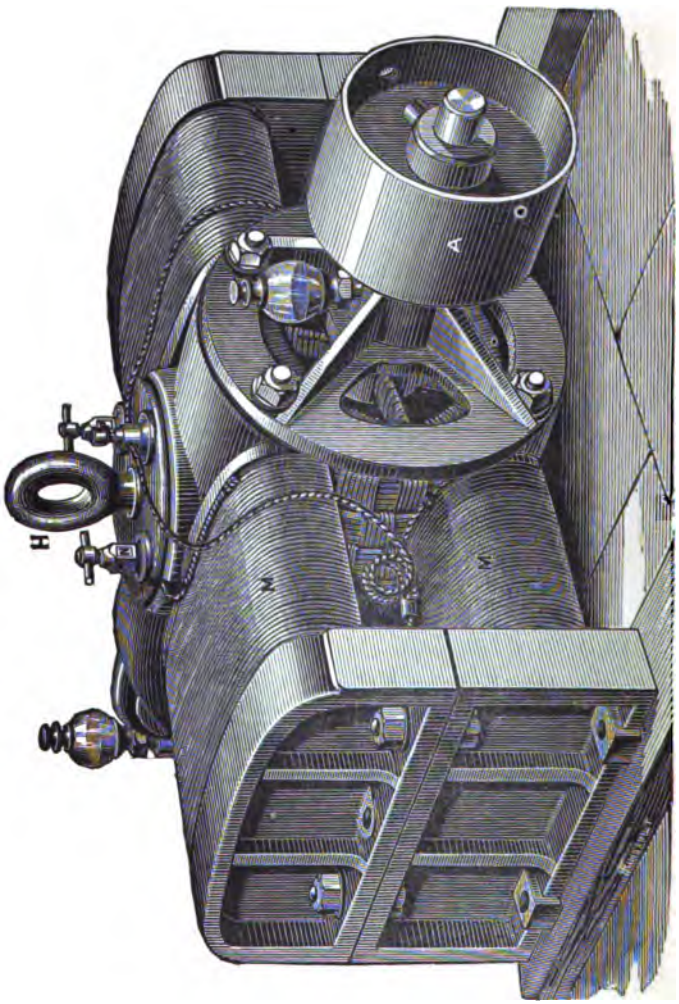


FIG. 7.—THE CROMPTON BÜRGIN DYNAMO MACHINE.

for arc lighting or for incandescent lighting purposes. When constructed for the latter work, the electro-magnets are specially

wound on the combined series and shunt principle, with a view

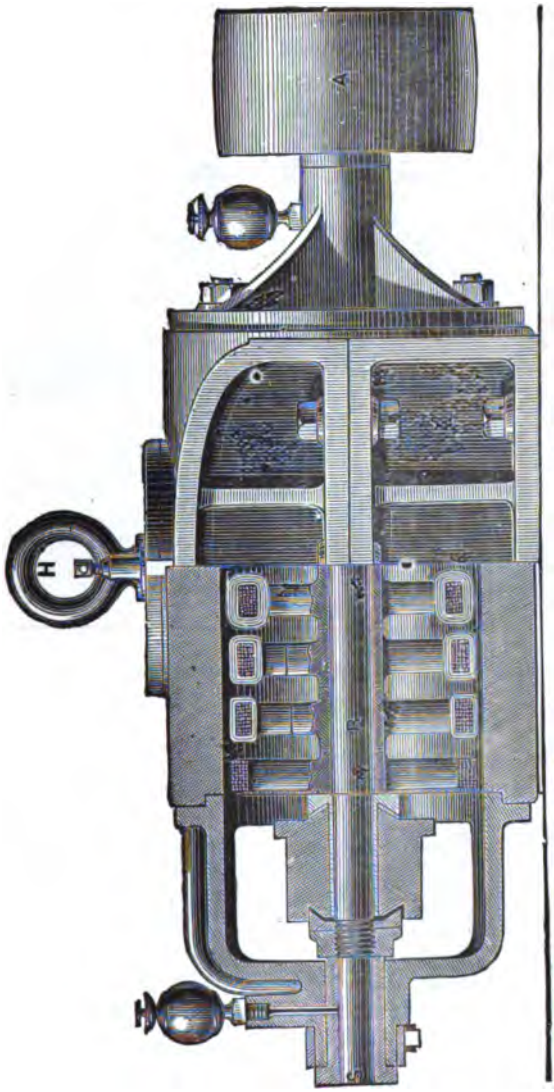


FIG. 8.—THE CROMPTON-BÜRGIN DYNAMO MACHINE.

of rendering the generation of the current automatically propor-

tional to the number of lamps in circuit, and keeping the electromotive force constant for a constant speed.

Fig. 7 is a perspective outside view, Fig. 8 is half a section

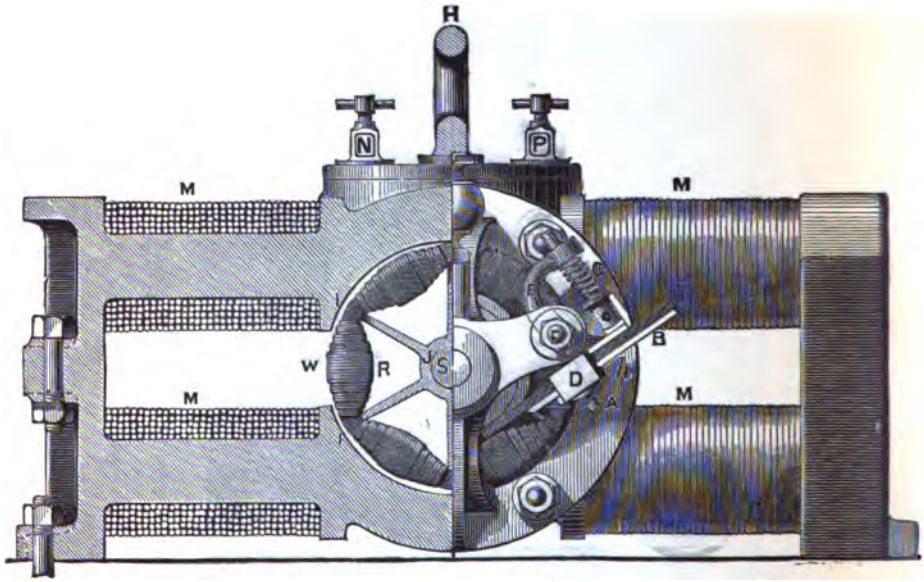


FIG. 9.—THE CROMPTON-BÜRGIN DYNAMO MACHINE.

FIG. 10.—THE CROMPTON-BÜRGIN DYNAMO MACHINE.

through armature parallel to shaft and half outside view, Fig. 9 a half section through electro-magnets and a half-end view, while Fig. 10 is a perspective view of the armature alone.

where N, P, represents the negative and positive terminals of machine;

M, M, the electro-magnets, which are two solid iron castings, planed, bolted together, and bored and faced to admit

R, armature ring, and receive the gun-metal end covers which form bearings for

S, spindle carrying the driving pulley, A,

B, B, two brushes for making contact with

C, commutator (Fig. 10). The sebrushes are fixed in

D, holder, and brought to bear upon C, by

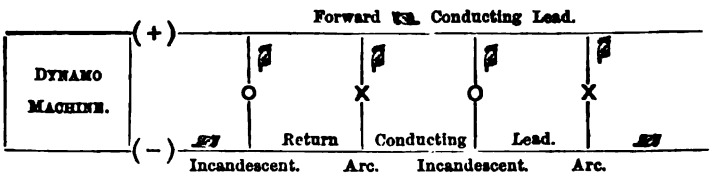
E and G, set screw and spring arrangement.

H, eye-bolt for lifting machine with.

The armature ring (Fig. 10) is one of the special features of this machine. It is the single Gramme ring split up into a large number of individual rings, R. The coils of wire, W, of these rings which are wound round hexagonal iron cores composed of soft iron wire, I, are connected in series to the sections of the commutator, C, where the current is collected in the usual way by two brushes, B. This machine has several advantages:—1. It lies low, is well constructed, and is free from vibration. 2. The armature coils are easily made and repaired. 3. The armature admits of being accurately balanced and rapidly rotated. 4. The small number of *layers* of wire on armature rings, with a free circulation of air *between* the spokes prevents undue heating.

We may here state that all dynamos on important circuits should be fitted with accurately indicating tachometers, or continuous speed indicators. This is a point which is too often neglected, although it greatly assists those in charge in keeping up a steady motion.

Gulcher Dynamo.—This dynamo (Fig. 11), the Gulcher Arc Lamp (see Figs. 16 and 17), and the Crookes Incandescent Lamp (see Fig. 18) form one complete low pressure system whereby arc and incandescent lamps are worked together all in parallel circuit, thus—



the arc lamps being used for the larger and more open spaces, such as workshops, while the incandescent lamps can be suitably distributed in the adjoining offices. The general construction of the Gulcher Dynamo will be understood from Fig. 11 and the following

INDEX OF PARTS,

where P, represents the driving pulley keyed on one end of
S, spindle carrying
A, armature (at centre) revolving between the poles of
M, M, electro-magnets (four on each side of A,)
C, Commutator (very broad) with
B, brushes (four in number 2 + and 2 —)
T + and T − terminals of machine to which the main forward + and return − conducting wires are attached.

The whole system was very efficiently shown at work during January and February last at Messrs P. & W. M'Lellan's warehouse, Trongate, Glasgow, where no doubt many of you had an opportunity of inspecting it. This installation consisted of one of Messrs Ransomes, Head & Jeffrie's portable steam engines, which was situated in the back-yard. The engine made about 120 revolutions per minute, and the dynamo, a No. 4 Gulcher, was driven direct from the fly-wheel by an 8-inch Oldfield & Walton's link leather belt, at 750 revolutions per minute, at which speed it generated a current of 72 volts, (electro motive force), and 120 Amperes, giving out 11½ horse-power of electricity. This current worked four Gulcher arc lamps and 60 Crookes incandescent lamps at one time, the arc lamps being placed in the open machine show room, while the

incandescent lamps were in some of the smaller rooms, and in the lower roofed front part of the building. The dynamo was pre-

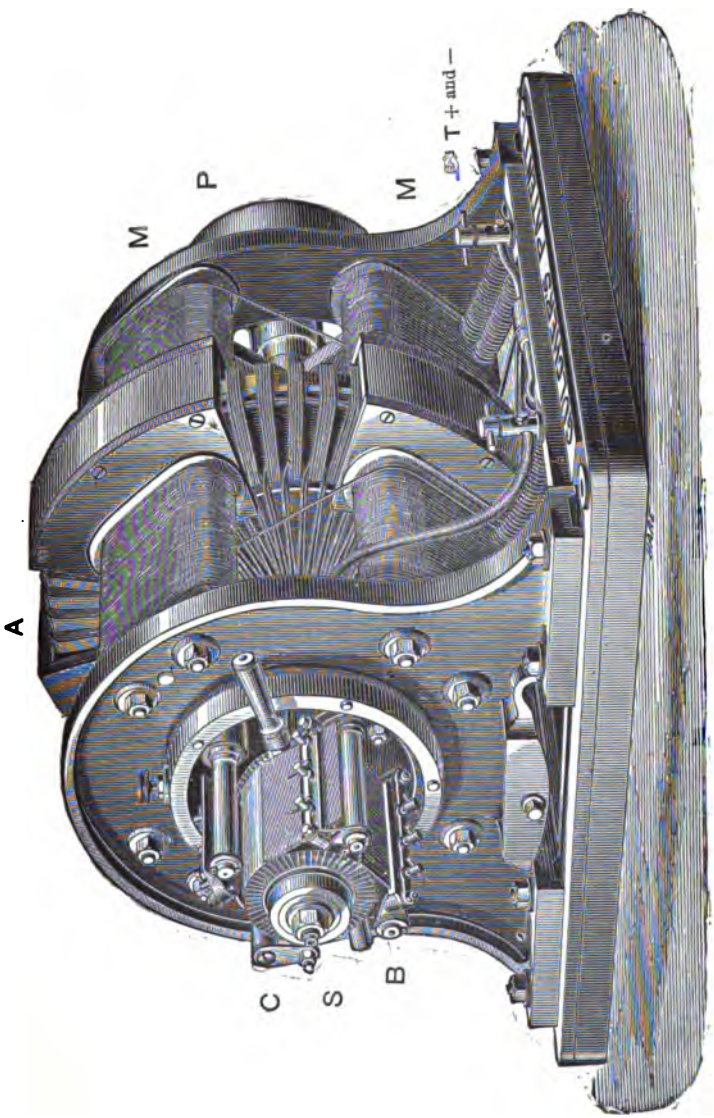


FIG. 11.—GULCHER DYNAMO MACHINE.

cisely the same as that shewn in figure 11, with the corresponding poles of each pair of electro-magnets, M, M, placed opposite to each other and connected together by an iron trough or shoe forming three sides of a square, so that not only the sides of revolving armature, A, but also the periphery are under magnetic influence. The transverse section of the armature A, is wedge-shaped in order to utilise to the utmost the magneto-electric induction on the wire coiled round its iron core, and the open way in which the wire is fixed is such as to create a draught and keep it cool. The commutator, C, as will be seen from the figure is extremely broad, and as the brushes bear upon it throughout its whole length, good contact and a freedom from sparking is ensured. The two + brushes are connected together, and the two — together, thus forming one large pair of + and — brushes, and reducing the internal resistance of the machine to a minimum.

Conducting Wires or Leads.

These should, in all cases, be carefully proportioned to the strength of the current they may have to carry, and to the distance through which it has to be conveyed; for, when electricity flows through resistance, energy is spent in heating the matter through which it flows. For practical use, the heat generated by a current of electricity in time, T, = $C^2 R T \times 0{\cdot}2405$ (gramme degrees),* where C = amperes, R = ohms, and T = seconds. Hence it is that if the conducting wire be too small for the current it has to convey, it will become warm, which still further increases its resistance—ultimately producing incandescence, and even fusion, endangering property by fire. Again, although the wire may have sufficient conducting power for the current, without undue heating at any part, yet its length, and consequently its resistance may be so great that the total amount of heat generated, or energy misspent on it, will considerably reduce the efficiency of the system.

---

* 1 Gramme degree = 42 million ergs (or Joule's equivalent), being the amount of heat required to raise 1 gramme of water from 0° to 1° cent. See Rankine's Rules and Tables (sixth edition, page 304).

Arc Lamps.

In dealing with electric lighting for workshops and large spaces above ground, I need only consider arc lamps, as neither the incandescent nor semi-incandescent lamp is so suitable as yet. I shall describe a few of them, in the alphabetical order of their names.

Akester's Lamp is one of the simplest forms of arc lamps that I have met with. It is arranged to be worked only as a single lamp; but there would be little difficulty in so winding a shunt coil, and fitting the extra necessary parts to it, as to make it serviceable to be worked in series with a large number of others of the same kind. Most of the modifications of arc lamps, of which there are so many patents, aim at keeping the + and — carbons at a uniform distance when in action, to produce a steady light. This is generally done by combined electrical and mechanical action.

Referring to Fig. 12, and

INDEX OF PARTS,

where S, S, represents solenoid coil of copper wire, No. 10 B.W.G., insulated by cotton and shellac varnish.
I, C, iron core (hollow).
F, S, quickly pitched six-threaded screw (1¾ in pitch).
N, nut with lower upturned milled edge.
P, pawl or lever held down by a bent spring.
C, H, carbon holders.
C+, C—, carbons 13 millimetres diameter.
G R, G R, parallel iron guide rods.
B C H, brass crosshead.

In this lamp the current, in passing from the dynamo to the upper carbon, traverses the solenoid coil, S, S, acting inductively on the hollow iron core, I, C, and sucking it upwards, thus lifting the upper from the lower carbon by engaging the nut N, which is fitted to the central feeding screw, F, S. The milled edge of the nut comes against the lever pawl, P, and is thereby prevented from turning round, thus limiting the length of arc. As the arc burns longer the resistance of the circuit increases, the current thereby necessarily diminishes in strength, and the lifting power of the solenoid becomes less, allowing the iron core to drop a minute

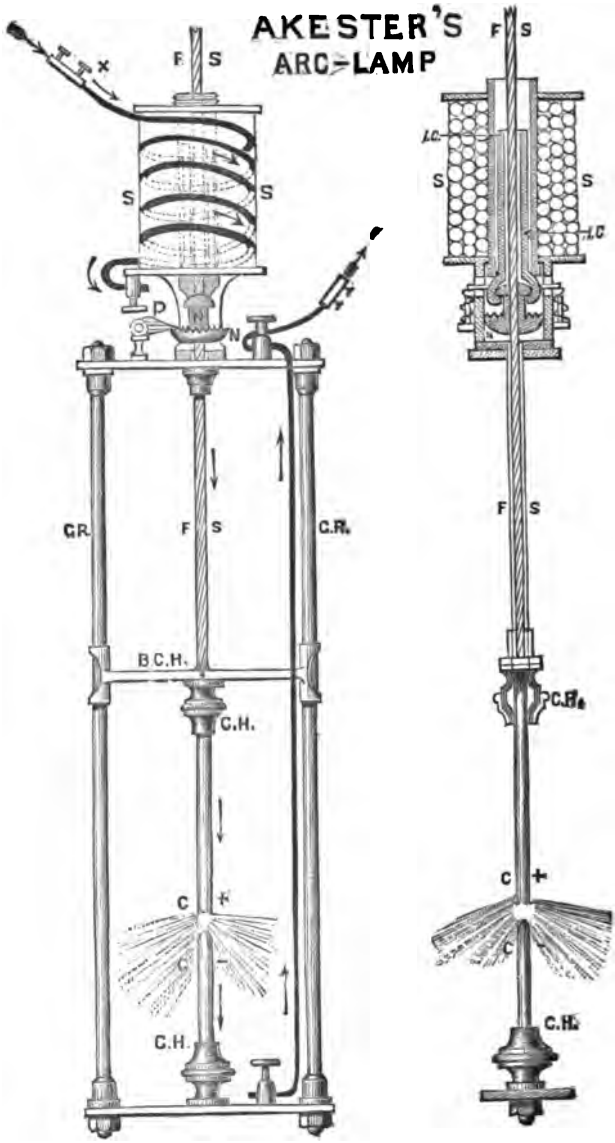

AKESTER'S
ARC-LAMP
F S
S S
P
N
C.R.
C.R.
F S
B C.H.
C.H.
C +
C −
C.H.
F S
LC
LC
S S
F S
C.H.
C +
C
C.H.

FIG. 12.

distance, just sufficient to clear the milled edge of nut, N, from the pawl, P, the nut turns round through a degree or two, which allows the carbon to drop a very small distance, the normal length of arc being in this way resumed. The above operation takes place so rapidly that the upper carbon is fed forward in almost perfect unison with the consumption, insuring a steady light.

From tests which I made of this lamp, with clear glass globes, an actual, not nominal, candle-power of 2,250 candles, or 1,450 candles per horse-power at the lamp, was obtained, the electricity being furnished by an A Gramme dynamo.

I would like here to explain and clear up an ambiguity which has arisen and which is very confusing to those not acquainted with electrical phraseology. When the expression, so many candles per "electrical horse-power," or so many candles per horse-power expended in the lamp, is used, it is to be understood that the electrical energy absorbed by the lamp, and developed in the form of heat and light, is, according to the formula $\frac{E \times C}{746}$, which we stated at the beginning of this lecture was an actual horse-power of 33,000 foot pounds per minute. This takes no account whatever of the energy lost in transmission through the leading wires, or that absorbed by the dynamo, or that spent on the moving parts of the engine shafting and belting through friction, &c. It is considered fairly good work, in actual practice, if we get 60 per cent. of the horse-power, as indicated by diagrams taken from the steam cylinder, in the form of electricity, at the lamp carbons or arc. The loss of power in conversion and transmission may be roughly computed as follows :—

Loss by friction, &c., in engine, &c.,	10	per cent.
„ in conversion of mechanical to electrical energy in dynamo, by heating, friction, &c.	20	„
„ by heating leading wires and lamp circuit coils, ...	10	„
Total loss,	40	„

One has therefore always to be on his guard when inquiring how much power such and such a lamp or system gives in the form of

light; and it is generally necessary to ask the question, "Do you mean so much cylinder horse-power, or so much dynamical horse-power, or so much in the form of electrical energy at the lamp?"

Brush Lamp (see Fig. 12).—Perhaps no lamp has been so extensively adopted as the Brush lamp in workshops and streets. Its popularity and success mainly depend upon the fact that it is arranged so that a large number can be included in series and worked from one Dynamo. As many as 40 of these lamps have

BRUSH LAMP.

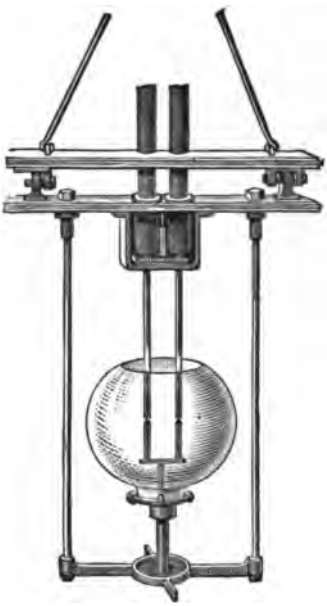


FIG. 13.

been worked, in numerous instances, by one machine, while the whole system is so adjusted by means of an automatic carbon regulator that one or more of the lamps can be extinguished or removed without endangering the others remaining in circuit. The only danger arising from using such a large number of lamps in circuit, placed in series, is the necessarily high electromotive force or difference of potential between the terminals of each lamp.

This force being 45 volts, 40 such lamps, *irrespective* of the leading wires and dynamo, require an electrical pressure of 1,800 volts, or about 2,000 volts including the dynamo and leads; and therefore the connections and leading wires should be well insulated, and the handling of the same should be done with care and caution. The normal strength of current is 10 ampéres, so that each lamp absorbs energy to the amount of E × C = 45 × 10 = 450 watts.

By comparing the theoretical diagram (Fig. 14) with Fig. 13, and the following description of details, the principle and action of the lamp will be easily understood. Only one coil and carbon are shown, for simplicity, although there are generally two.

INDEX OF PARTS.

where T + and T — represent lamp terminals.

F, C, hollow feed coil with thick copper wire (0·12 Ohm resistance) wound round it in a right-hand spiral, terminating at

S, C, slip contact bearing on carbon holder.

Also round F, C, is wound a thin copper shunt wire (160 Ohms) in a left-hand spiral. This fine wire is continued to and wound round

C, O, cut-out coil (40 Ohms) to terminal T —

I, C, iron core, which is sucked up inside F, C, under the preponderating influence of the stronger current passing through the thick wire against gravity, and against the effect of the weaker current passing through the fine shunt wire, thus lifting

L, lever which tilts

W, washer or clip ring, which in turn lifts

C + upper carbon from

C — lower carbon, thus forming the arc.

The upper carbon falls towards the lower one periodically, being automatically retarded in its progress by the action of the varying proportions of current passing through the thick and thin wires of the feed coil, F, C, due to the varying length and consequent resistance of the arc.

The cut-out coil is also wound with a thick copper wire in the

same direction as the fine wire around it, but the thick wire is only brought into circuit on the carbons burning out, or extinguishing of the lamp and breaking the arc through an accident. Should this take place a greater proportion of current than usual flows through the fine wire, strongly magnetising the iron core of

THEORETICAL DIAGRAM—BRUSH LAMP.

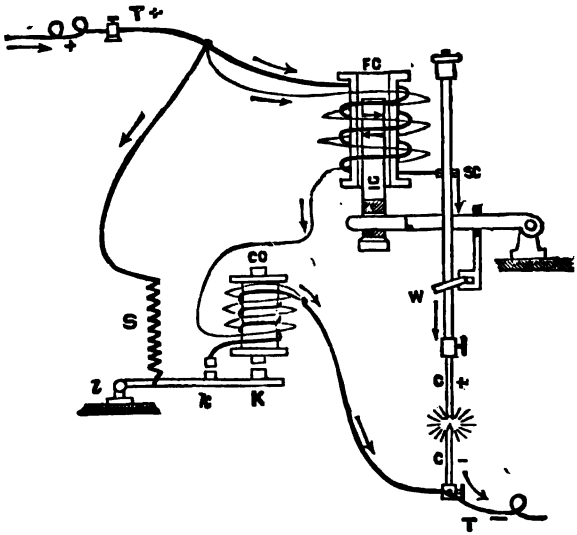


FIG. 14.

the cut-out coil, C, O, which attracts the iron keeper K, fixed to lever, *l*, thus establishing a low resistance circuit for the main current by way of spring, S, lever, *l*, contact, *k*, through thick wire of C, O, to terminal (T —), and thence to the next lamp in the series, effectually cutting the lamp in question out of circuit until put to rights.

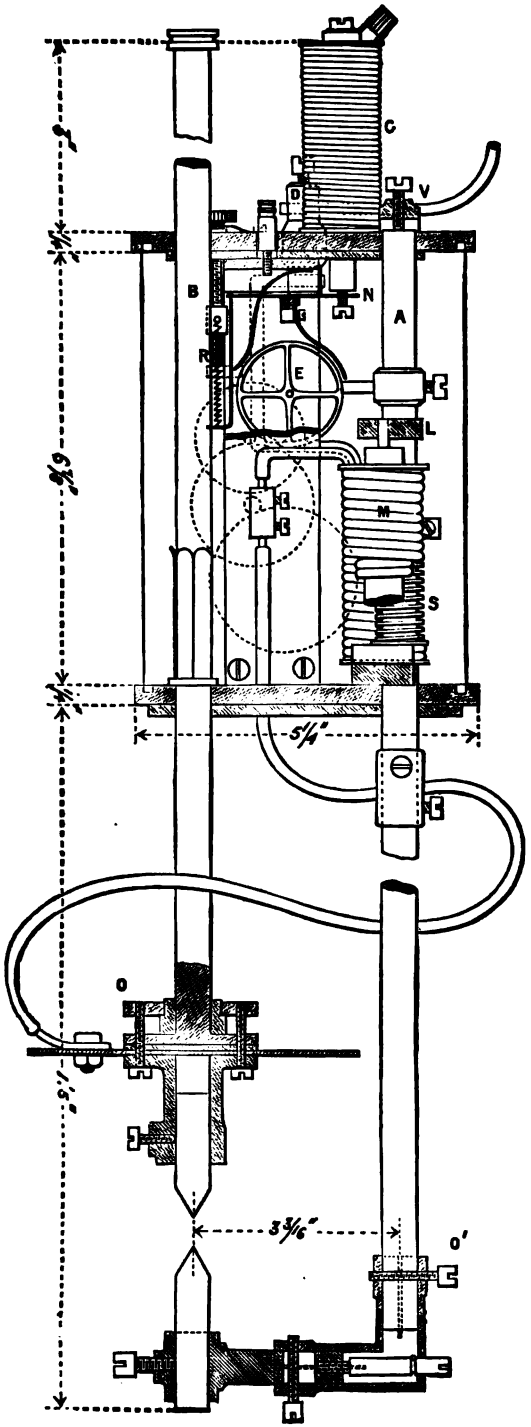
I tested the candle-power, the other day, of one of the Brush lamps at the Aberdeen installation, where they have dispersed along Union Street, Market Street, &c., in a circuit of a mile and a half, 16 lamps of 2,000 (nominal) candle-power, and found it to give 567 candles, measured at an angle of 30 degrees from the horizontal. The lamps are placed on 20-feet wooden poles,

and the centre of the arc of the one which I measured was 20 feet 10 inches from the ground, which appeared to be a very suitable height for distributing the light. The lamp was fitted with clear glass globes, which, from various tests which I have made with clear glass, will reduce the candle-power about 10 per cent. of that given by the naked light. I also tested one of the 32 Brush lamps daily at work at Messrs Mirrlees and Watson's engine works, where they use strongly frosted globes with a view to soften and diffuse the rays of light and render it more agreeable to work under. These globes reduce the candle-power about 50 per cent., and the mean which I got was 310 candles. The workshop engine is used, and it appears that 17 lamps are worked by one machine for an expenditure of 19 indicated horse-power, as measured by diagrams taken from the cylinder; or, say roughly, 1·1 indicated horse-power per lamp, or 54·5 per cent. of the horse-power developed in the cylinder is usefully employed in the form of electricity at the lamps.

The Crompton Arc Lamp.—This lamp is very suitable for railway stations and large spaces where a powerful light of 2,000 or more candles is desirable, and where plenty of elevation can be obtained.

Referring to Fig. 15, it will be seen that the upper part, which contains the mechanism, consists of a pair of top and bottom plates, united by a pair of flat frame plates, which form the sides carrying the train of wheel work. The upper carbon holder terminates in (B) a solid rod of brass, with a rack cut on one side of it. This rack gears with the largest and lowest wheel of the train. The top wheel (E) of the train is termed the brake wheel, and is fitted with a centrifugal governor to regulate its speed. The brake mechanism, N, consists of a lever pivoted on its centre, so that when the end, N, is attracted towards the pole of the shunt coil magnet, C, it overcomes the tension of spring, R, and releases the brake wheel, E, allowing the upper carbon to fall by gravity towards the lower one. So long as no current is passing, the spiral spring, S, pushes up the tube, A, carrying the lower carbon holder O, so that the carbon points are in contact; but whenever a current of sufficient strength passes through the electro-magnets, M M, the armature, L, is attracted downwards

CROMPTON ARC LAMP.



towards its iron cores, and with it the tube, A, to which it is fixed, thus separating the carbons, and forming the arc to its normal length. While this normal length of arc is maintained, a constant but small proportion of the main current passes through the high resistance shunt coil, C, which is connected between the main terminals of the lamp, just sufficient to maintain the brake mechanism (described above) in equilibrium. A very slight increase in the length, and consequently in the resistance, of the arc causes more current to pass through the shunt coil C, which then releases the brake from wheel, E, and allows the upper carbon to descend until the arc again assumes its normal length. The feed mechanism is therefore entirely actuated by the varying resistance of the arc causing a greater or less proportion of the total current to pass through the shunt coil, C.

Messrs Crompton's firm state that they obtain by this lamp effective lighting for 200 square yards of station floor area, both at Queen's Street Station, Glasgow, and King's Cross Station, London, for an expenditure of only one pound of coal per hour, by using Messrs Marshall & Son's economical engines. You have, no doubt, all witnessed the performance of this lamp at Queen Street Station, Glasgow, and I think every one admits that it is the best lighted station in the kingdom. Mr Hobson, the Postmaster, is so well pleased with this lamp at the General Post Office that he has entered into a two years' working contract for the lighting up of the larger spaces in the Post Office, while the smaller offices and rooms are to be lighted, within a few weeks, by means of Swan's lamps.

I think arc lamps, both in railway stations and workshops, should be so placed with regard to distance apart and height, that no part where work or business has to be carried on should have less light than that equal to one standard candle at 2 feet distance. For the Brush lamp, reckoning them as averaging 500 candles with clear globes, this would mean placing them at a height of 22½ feet and 26 yards apart, and would give a good light to read or work by, while not too strong or trying to the eyes. For streets, the Brush lamps might be placed at a height of 22½ feet and about 60 yards apart, or with a minimum light at the furthest parts from the lamps of about equal to 1 candle at

4 feet distance. In workshops, streets, and large spaces, the lamps should be so placed zig-zag that the light from each tends to dispel or cancel, as far as possible, the shadows cast by the others.

It is worthy of mention that Messrs A. & W. M'Onie, who have lately adopted the Brockie lamp worked by the A Gramme dynamo are able to photograph their working drawings by means of the electric light. They have fitted up a special room for the purpose, and obtain a clearly-defined copy of a drawing 3 feet 6 inches by 2 feet 6 inches in twenty minutes. The light is placed 2½ feet from the drawing, and the latter moved to the right or left until the whole photograph is equally well brought out.

*Gulcher Arc Lamp.**—This lamp, which is a very simple one, is designed and adjusted so as to work in "parallel" with others of the same pattern, or with incandescent lamps. The general construction and action will be understood by referring to Figs. 16 and 17 and the following

INDEX OF PARTS (FIG. 17),

where T + and T — represent the + and — terminals attached to the main forward and return conductors by branch leads.

E, M,	An electro-magnet balanced on an axis and capable of rotation through a small angle.
I, K,	Iron keeper (fixed to frame of lamp).
I, C, H,	Iron carbon holder for upper carbon (in centre).
C + C −	Carbons.

The electro-magnet E,M, is in the main circuit of the lamp, and upon a current being passed from T + to T— through it, the right hand pole of E, M, is attracted upwards by the mutual magnetic action between it and the fixed iron keeper I,K, while at the same instant the left hand pole of E, M, attracts and binds the iron carbon holder I, C, H, lifting it and the upper carbon with it as it turns upwards, thus forming the arc. By means of

* This lamp, along with Crooke's Incandescent Lamps, kindly lent by the Scottish Gulcher Coy., were exhibited and described at the meeting.

a tension spring shewn on the upper side of the electro-magnet, its lifting power can be easily adjusted, so that as the carbons burn away and the arc gets longer, and consequently the current weaker, this spring acting against the lifting power of the electro-magnet pulls it down, thus causing the left hand pole to free its hold upon the iron carbon holder I, C, H, and allow the upper carbon to fall a short distance, and thus readjust the arc to its normal length. When there are two or more of these Arc lamps

FIG. 16.—GULCHER ARC HANGING LAMP.

in parallel circuit, the resistance of each mutually causes the current passing through it to react upon the others, effectually creating an equilibrium between them all, and producing a very steady system, when the whole has been properly adjusted and

set agoing. The following tests which I made of the Gulcher Arc Lamp will be interesting, there being in circuit at one time four arc lamps and 59 incandescent (Crookes's) lamps.

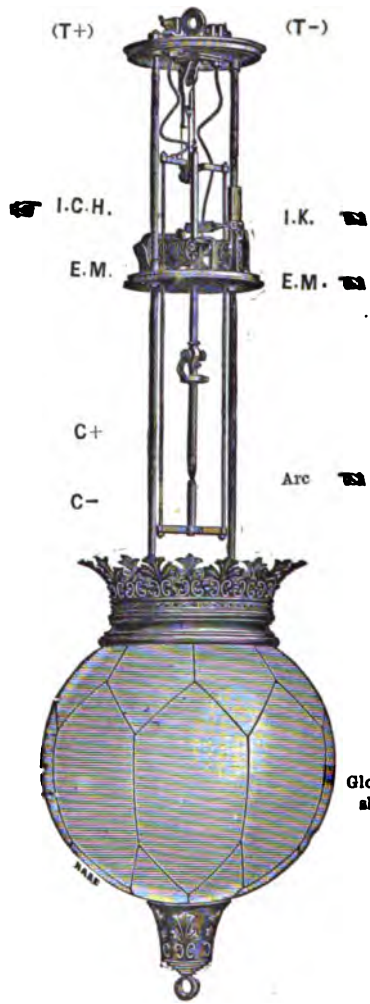


FIG. 17.—GULCHER ARC HANGING LAMP. SHEWING WORKING PARTS.

E.M.F. Between terminals. E Volts.	Current. (C) Amperes.	Candle power. Globe on.	Candle power. Naked arc.
71.	13·4.	510.	1050.

For coal pit heads it will be found best to burn the lamp with a naked arc, as you get about double the candle power from it as compared with that when the frosted globes are on.

ELECTRICAL INSTRUMENTS FOR MEASURING THE STRENGTH OF CURRENT AND THE ELECTROMOTIVE FORCE.

The development of electric lighting has necessitated the invention of special instruments for measuring stronger currents and greater electrical pressures than were demanded by those used for submarine and other telegraphic and scientific purposes, and we are fortunate in being able to place before you this evening those of Professors Ayrton and Perry. These instruments were explained and the way in which electricity is measured and might be charged for quarterly was referred to.

RELATIVE COST OF ELECTRIC AND GAS LIGHTING FOR WORKSHOPS AND SURFACE WORKS.*

We now come to compare the relative cost of electric lighting and gas lighting.

There can be no doubt that the introduction of electric lighting has greatly spurred on inventors and gas managers to make more of the gas than formerly, and the consequence is that we have gas burners rivalling the electric light both in brilliancy and economy.

There are being fitted at the present moment, to the Clyde Navigation Graving Dock, a large number of Bray's powerful gas lamps. Also, the Clyde Trust have in operation one of Siemens' 400-candle power lamps, and are having fitted up 20 of Siemens' patent regenerative 130-candle power gas burners, in place of the former mode of lighting by 30 cowl-shaped crystal basins, each

* The case as stated does not exactly apply to coal pit heads, but the author is strongly of the belief that it will be found cheaper and better in every way if these works were lit by the electric light, and he is willing to prove it to any members of the Institute who may think of adopting it.

containing four No. 4 gas jets. Each of these systems of gas lighting has certain advantages which the other does not possess, and for each certain advantages are claimed against that of electric lighting. Undoubtedly the Siemens burner is more economical than Bray's, as far as the amount of light given out for a certain consumption of gas is concerned, for it is found that while the Bray lights give 5·7 candles per cubic foot of Glasgow gas, the Siemens burner—as we shall prove further on—yields 7·8 candles per cubic foot of the same gas; but then the Bray lights admit of being turned down to one small jet, when the full flame is not required, more readily than the Siemens burner.

From tests made by Dr. Wallace and myself of these Siemens burners, it appears that 408 candles are obtained from a consumption of 52·2 cubic feet per hour, or 7·8 candles per cubic foot; or say 39 candles for 5 cubic feet per hour, or an improvement in the economy of using gas of 46 per cent. over that of the best small burner which is used in testing the Glasgow 26-candle gas (*i.e.*, 26 candles for 5 cubic feet per hour).

Let us compare this with the Brush lamp under similar conditions as to globes and lanterns. We got 567 candles from the Brush lamp at Aberdeen with clear globes.

Cndls. Cndls. Cb. ft.
$\therefore$ 408 : 567 :: 52·2 : $x = 72{\cdot}5$ cubic feet per hour

of Glasgow gas required by Siemens' burner to produce 567 candles. Now Glasgow gas costs 3s 8d per 1000 cubic feet.

Cb. ft. Cb. ft.
$\therefore$ 1000 : 72·5 :: 44d. : $y = 3{\cdot}19$d. for gas alone per hour.

To this we have to add, say, 20 per cent. on first cost of lamps and fittings (£30), as well as depreciation on same—or £6 per annum. Allowing this to be distributed over 3650 hours, or 10 hours' lighting per day, we have

Hours. Hour.
3650 : 1 :: 1,440d. : $z = 0{\cdot}39$d. per hour

for interest and depreciation of plant. We have also to count

something for attendance, and this cannot be reckoned at less than one farthing per hour per lamp. Adding these sums, we have

3·19d.	per	hour	for gas.
0·39d.	,,	,,	interest, &c.
0·25d.	,,	,,	attendance.
Total cost, 3·83d.			per hour.

And this with by far the most economical method yet derived for burning gas.

The Brush Company of Scotland say they are willing to lay down all the necessary plant, including steam boiler, engine, dynamo, leads, lamps, &c., complete, and guarantee their proper working, paying all expenses, including carbons, &c., for a system of 40 arc lamps, to any person or combination of persons within reasonable distance of each other, and charge them only 3d per hour per lamp during every 3650 hours of lighting per annum. This is a straightforward and practical way of putting it; and should the lights be required for a proportionately less time per annum than the 3650 hours, they will be able to tell you the small fractional extra expense per hour which it will cost.

I have been informed by Messrs Bray & Co. that the price per hour for each of their 500 candle-power glass lanterns burning in Glasgow, at full power, for 2000 hours per annum, would be 4·375 pence. This estimate includes erection, interest, and maintenance of plant in good working order. If, however, their double-service system be adopted—that is, lowering the lamps at midnight to one jet of 30 candles (or 1000 hours at 500 candles and 1000 at 30)—the price is reduced to 2·875 per hour per lamp. The above does not include lamplighters' wages, which we may reckon at one farthing per hour per lamp as before.

INCANDESCENT LAMPS FOR ROOMS, OFFICES, OR COAL WORKINGS.

*Crookes's Incandescent Lamp.**—This modification of the Edison and Swan incandescent lamp does not in any way differ from them

* Members can refer back to Vol. III., p. 145, for Prof. Jamieson's full description of the construction and action of the Swan Lamp. A very small five candle-power Swan lamp worked from the Gramme dynamo was shewn at the meeting; and some of Crookes's as well as Lane Fox's lamps were also exhibited.

in principle or action, the chief points claimed by Mr Crookes being the construction of a pure, dense, and structureless carbon filament (attached to short platinum wires), hermetically sealed

CROOKES'S INCANDESCENT LAMP.

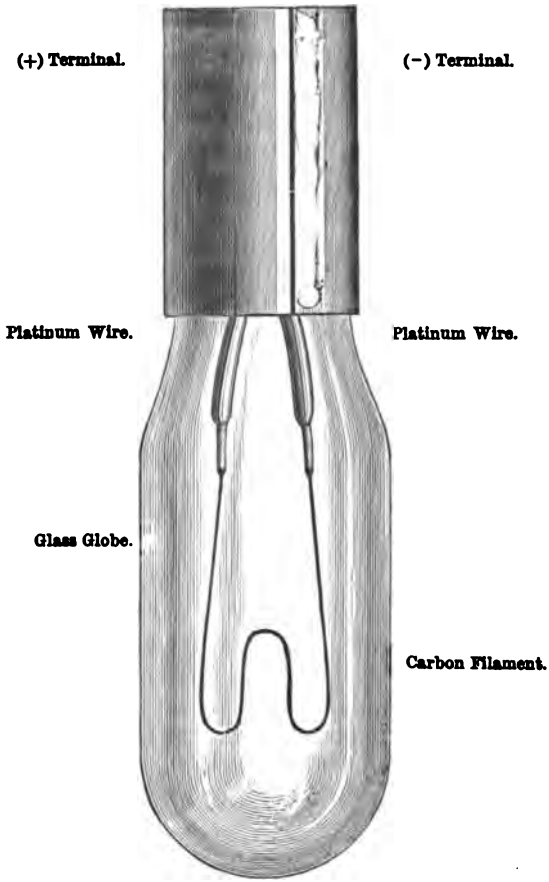


FIG. 18.

in a glass globe, from which the whole of the air has been extracted by means of a special form of vacuum pump. The life of the tiny carbon filament very greatly depends upon there being

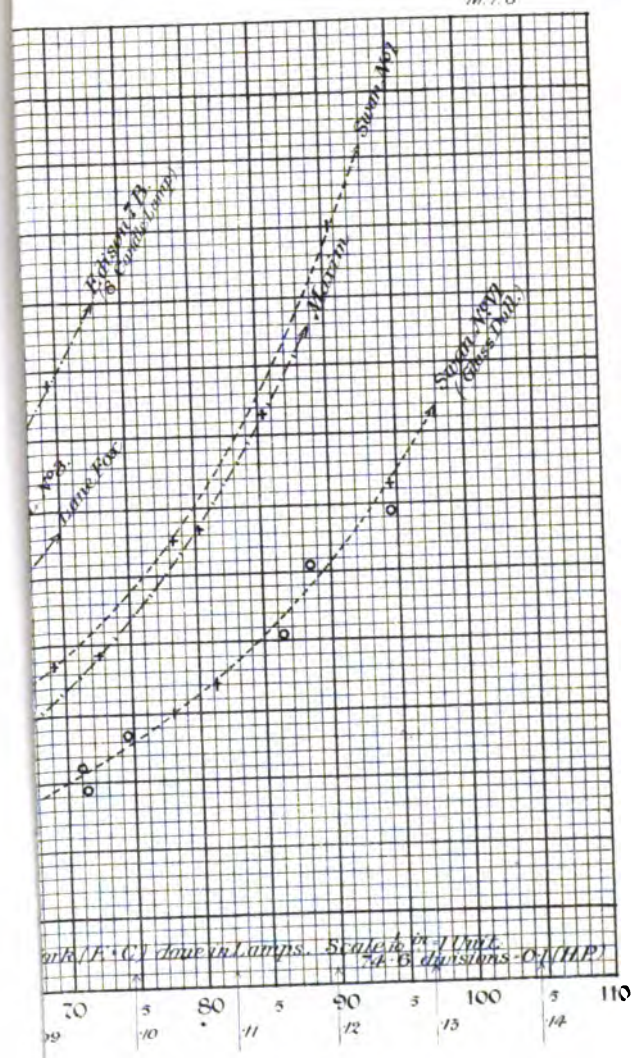
as perfect a vacuum within the glass globe as possible; and, had it not been for a knowledge of how to produce this high state of rarefaction, incandescent lamps could never have attained to their present success, or glowed even as many minutes as some of them have now done hours at Earnock Colliery. Mr Crookes was the first to produce these very high vacua. His extensive and elaborate researches, extending over a number of years, in connection with this interesting and delicate operation, really paved the way for the introduction of incandescent electric lighting, which, in many other but minor details, had been tried, and proved a failure, due to the rapid combination of the carbon filament with the oxygen of the atmosphere when in a heated condition under the influence of the electric current. Now, the most perfect vacuum imaginable can be produced in a simple and inexpensive manner, and there is every prospect that the average life of a good incandescent lamp, glowing at its normal candle power, may yet be considerably over 1000 hours. It is, however, found that any attempt to press such lamps above a certain temperature considerably shortens the period of their existence, and the wonderfully long life of the Swan lamps at Earnock Colliery is no doubt due, in a great measure, to their having been carefully worked at a low candle power.

Edison Lamps‡.—At the meeting, you had the satisfaction of seeing ten Edison lamps successfully worked by the Brush Coy.'s dynamo, driven by the Otto gas engine, situated in the *Advertiser* machine-room, near the lecture hall. These lamps were giving out quite 16 candle power each, and you could readily judge from their position before you of their suitability for illuminating offices and dwelling-houses. You could imagine how still more effective they would appear if compared with the usual form and power of light with which you are supplied below-ground in your coal mines. The expense, as far as the application to coal mines is concerned, is chiefly a matter of first cost, and when you have observed that within the course of two years the price for each lamp has fallen from 25s to 3s 6d, and the plant, has also been greatly reduced in

‡ One dozen Edison lamps were sent to the meeting by Edison's Glasgow Agent.

price (although not in the same ratio), it certainly appears likely that, taking into account the advantages of this form of lighting for your pit bottoms, (I do not refer to the working faces), it is worthy of your special notice not only from a strictly scientific, but also from a commercial point of view. In conclusion, I would draw your attention to the plate of curves (Plate VI.), showing the ratio of candle-power obtained to horse-power (in the form of electric energy) spent on such lamps. I have to thank your Secretary for so kindly and readily assisting us in getting the various machines and apparatus in order for the lecture; in fact, had he not done so it would have been quite impossible for me to have shown the different lights at work, owing to short notice and the limited time at my disposal.

PLATE VI
M.I.S



ork/[F.·C.] done in Lamps. Scale to fit 1 Unit.
A·C dimensions -O-[HP]

TESTS OF INCANDESCENT LAMPS.

Lamp.	Res. Cold by Bridge = (r).	Res. Hot, Ohms = (R).	E.M.F. Volts. = (E).	Current in Ampères = (C).	Candle-power = (K).	No. of Candles per Horse-power $= \frac{K \times 746}{E \times C}$	No. of Lamps per Horse-power $\frac{746}{E \times C}$
Swan, .	66	33·0	40·14	1·22	8·5	130	15·27
„ .	„	32	47·6	1·49	21·6	225	10·5
„ .	„	31·1	51·64	1·67	34	293	8·6
B.E. Coy.,	158	76·5	61·4	·80	9·8	148	15·2
„	„	71	71	1·0	30	313	10·4
Edison B,	116	61	51·9	0·85	8·2	138	16·9
Lane Fox,	188	98	66·	0·673	8·7	146	16·8
Maxim, .	73	39·4	44·2	1·12	7·1	107	15·0
„	„	39·1	48·9	1·25	14·6	178	12·2
„	„	38·2	52·7	1·38	24·3	249	10·3
Gatehouse,	88	46·2	60	1·3	20	191	9·6
Akester, .	80	41	57·3	1·4	20	186	9·3
Crookes, .	119	66·7	70·7	10·6	21	209	10·0

THE

MINING INSTITUTE

OF

SCOTLAND.

RULES,

AS REVISED AT THE ANNUAL MEETING, 12TH APRIL, 1883, AND A SPECIAL MEETING, 24TH MAY, 1883;

LIST OF MEMBERS, 1882-83;

CATALOGUE OF LIBRARY.

HAMILTON: PRINTED BY WILLIAM NAISMITH.
1883.

THE MINING INSTITUTE OF SCOTLAND.

RULES,

AS REVISED AT THE ANNUAL MEETING,

12th April, 1883

SECTION I.—OBJECTS.

I.—The objects of this Institute are to enable its Members to meet together at fixed times to discuss the means for the ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the Advancement of the Sciences of Mining and Engineering.

SECTION II.—CONSTITUTION.

I.—The Institute to consist of Ordinary Members, Life Members, and Honorary Members.

II.—The Council of the Institute for the management of its affairs shall be chosen annually from the Members, and shall consist of a President, Four Vice-Presidents, Twelve Councillors, a Secretary, and a Treasurer.

SECTION III.—QUALIFICATION OF MEMBERS.

I.—Ordinary Members to be persons practising as Colliery Managers, Mining, Civil, or Mechanical Engineers, and other persons connected with, or interested in, Mining and Engineering, of whom the Council may approve.

II.—Life Members to be persons who shall compound for all future payments by a payment of Ten Guineas, or on such conditions as the Council may in writing accept.

III.—Honorary Members to be persons of whom, although not technically qualified, the Council may approve.

Section IV.—Election and Expulsion of Members.

I.—A recommendation for admission, according to Form A, in the Appendix, to be forwarded to the Secretary, and by him to be laid before the next meeting of the Council. The recommendation to be signed by Two Ordinary Members or Life Members.

II.—The Election to take place at a General or Special Meeting by ballot; three-fifths of the votes tendered being necessary for election.

III.—In the case of non-election, no mention thereof shall be made in the minutes, nor any notice given to the unsuccessful candidate.

IV.—When the proposed candidate is elected, the Secretary shall give him notice thereof, according to Form B, but his name shall not be added to the list of Ordinary Members or Honorary Members until, and unless, within two months after notice of election as above, he shall have paid his first annual subscription, and signed the Form C, whereupon he shall be entitled to all privileges of Membership, including a copy of the Transactions issued in that year.

V.—The Transactions of the Institute shall not be forwarded to persons whose subscriptions are more than six months in arrears.

VI.—Any person whose subscription is twelve months in arrear shall be reported to the Council, who shall direct application to be made for it, according to Form D, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after suitable remonstrance by letter, in the form so provided (Form E), of erasing the name of the defaulter from the register of the Institute.

Section V.—Election of Officers.

I.—The election of Officers shall take place at the Annual General Meeting in the month of April in each year.

II.—The President, the Vice-Presidents, and Councillors to retire annually; but they shall be eligible for re-election with the exception of one Vice-President and the three Councillors who may have attended the fewest Council Meetings during the past year, and when such attendances are equal, the Council shall decide which of the Vice-Presidents and Councillors shall be re-nominated; but such persons shall be eligible for re-election after being one year out of office.

III.—Candidates to be put in nomination at the General Meeting preceding the Annual General Meeting, when the Council shall present a list of their retiring members who offer themselves for re-election. Any member to be entitled to add to the list of Candidates. In case of the decease or resignation of any Officer or Officers, notice thereof must be given at the next General or Special Meeting, and a new Officer or Officers elected at the succeeding General or Special Meeting, in accordance with the mode above-mentioned.

IV.—The Secretary and Treasurer shall be appointed every year by the Council, at the first meeting of the Council after the Annual General Meeting.

Section VI.—Meetings.

I.—There shall be Nine Ordinary General Meetings in each year, to be held in Hamilton, unless elsewhere arranged for by the Council. The Annual General Meeting to be held in the month of April.

II.—A Special Meeting of the Institute to be called whenever the Council may think fit, and also on a requisition to the Council distinctly specifying the reason thereof, signed by ten members.

III.—The Ordinary Members, Life Members, and Honorary Members to have notice of, and the privilege to attend all General and Special Meetings; but Ordinary Members and Life Members only to be entitled to vote on any question by ballot or otherwise.

IV.—Every question, not otherwise provided for, which shall come before any Meeting of the Institute, shall be decided by the votes of the majority of the Members and Life Members then present. But the Council shall have the discretionary power of suspending the effect of such decision, if by them considered to be prejudicial to the interests of the Institute; and of referring the same to a special or to the next General Meeting, and at least ten days before such meeting, the Secretary shall have sent, by printed circular, to every person enrolled in the Institute, explicit notice of the question in abeyance.

V.—Invitations shall be forwarded by the Council to any gentleman whose presence at the discussion they may think advisable; and strangers so invited shall be permitted to take part in the proceedings, but not to vote.

VI.—Any person enrolled in the Institute shall have power to introduce a friend or stranger (see Form F) to any of the General Meetings of the Institute, but such visitor shall not take part in the proceedings, except by permission of the meeting.

VII.—No alteration of the Rules to be made at any but the Annual General Meeting, or at a Special Meeting for that purpose; and the particulars of every such alteration shall be announced at a previous General Meeting and inserted in the minutes; and such Annual or Special Meeting shall have power to adopt any modification of such proposed alteration of, or addition to, the Rules.

Section VII.—Subscriptions.

I.—The Annual Subscription of each Ordinary Member shall be 10s 6d, excepting Coalmasters, Agents, Civil, Mining, and Mechanical Engineers, and other Members interested in but not actively engaged in Mining, whose Subscription shall be £1 1s.

II.—All Annual Subscriptions to be payable in advance, and the same are to be considered due and payable at the April meeting of each year, or immediately after election.

Section VIII.—Communication by Members.

I.—All papers shall be submitted to the Council fourteen days before the date when it is proposed that they be read, and the Coun-

cil shall have power to decline any papers. The Council shall direct whether any paper read before the Institute shall be printed in the Transactions; and notice shall be given to the writer within one week after it has been read, whether it is to be printed or not.

II.—The Council shall have the power to publish any or all of the communications as they may think proper.

III.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use, and such a further number given him at cost price as may be approved of by the Council.

IV.—All proofs of discussion, forwarded to persons who have taken part therein for correction, must be returned to the Secretary within two days from the date of their receipt, otherwise they will be considered correct and be printed off.

V.—The Institute is not, as a body, responsible for the facts and opinions advanced in the papers which may be read, and in the discussions which may take place at the meetings of the Institute.

The copyright of all papers communicated to, and accepted for printing by the Council and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise without the written permission of the Council.

SECTION IX.—DUTIES OF THE OFFICERS AND COUNCIL.

I.—The President to be Chairman at all Meetings, and, in his absence, one of the Vice-Presidents. In the absence of a Vice-President, the Members present to elect a Chairman for that Meeting.

II.—The Funds of the Institute shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

III.—The Secretary shall be present at all the Meetings, and shall take minutes of the proceedings and read those of the preceding Meeting; but, in the case of unavoidable absence, the Council to appoint some one to act for him.

IV.—All past Presidents shall be *ex officio* Members of the Council so long as they continue Members of the Institute; and Vice-Presidents, not re-elected, shall be *ex officio* Members of the Council for the following year.

V—At Meetings of the Council five shall be a quorum, and the minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute. The President shall be *ex officio* chairman of every committee.

VI.—The Council shall have power to revise and correct proofs of communications and the discussions thereon, and to delete any portion or portions of the discussion which may be by them deemed unsuitable for publication.

VII.—At the Annual General Meeting the Council shall present a report of the proceedings, and an abstract of the accounts of the previous year, audited by two Ordinary Members who are not Members of the Council.

Section X.—Property of the Institute.

I.—All the Property of the Institute to be held by the Council in trust for the Institute.

II.—All Books, Drawings, Communications, &c., shall be accessible to all the Members of the Institute; and shall be held in trust by the Council, at the Rooms of the Institute in Hamilton, for the use of the Members.

III.—None of the property of the Institute, as Books, Drawings, &c., to be taken out of the Rooms of the Institute without the consent of the Council.

IV.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members or others, unless by written order from the Council.

V.—All donations to the Institute shall be enumerated in the annual report of the Council to the Members.

Section XI.—Disputes.

I.—Any difference of opinion arising regarding the interpretation of any of the foregoing Rules to be submitted to the Council, whose decision shall be final.

BY-LAWS.

I.—The General Meetings to be conducted, as far as practicable, in the following order :—

1st.—The Chair to be taken at Six p.m.

2nd.—The minutes of the previous meeting to be read by the Secretary or person appointed, and, after being confirmed, to be signed by the Chairman of that meeting.

3rd.—The balloting of new nominations for membership shall be proceeded with and the result announced.

4th.—Communications by letter to be read by the Secretary, according to priority of date.

5th.—Communications from the Council to be read by the Secretary.

6th.—Discussion will be invited upon a paper or papers read at a previous meeting, copies of which, if printed, will have been circulated among the members.

7th.—The paper or papers announced for the meeting will be read.

8th.—With a view to the maintenance of order during discusssions, and to prevent them from degenerating into mere conversations, no remarks will be considered in order unless the speaker is standing.

II.—Any member changing his residence to give notice in writing to the Secretary.

APPENDIX.

[FORM A.]

Name in full, Mr
Designation or occupation,
Address,
being desirous of admission into the Mining Institute of Scotland, we, the undersigned, propose and recommend that he shall become a thereof.

Proposed by } } Signature of two Members.

Dated 18

See Rules.

Section III.—Qualification of Members.
Section IV.—Articles I. and II.—Election of Members.

[FORM B.]

SIR,—I beg to inform you, that on the day of you were elected a of the Mining Institute of Scotland; but, in conformity with its Rules, your election cannot be confirmed until the enclosed Form be returned to me with your signature, and until your first annual subscription, £ , be paid.

If not paid within two months from this date, the election will be void, under Rule IV., Section IV.

I am, Sir,
Yours faithfully,

Secretary.

Dated, 18

[FORM C.]

I, the undersigned, being elected an of the Mining Institute of Scotland, do hereby agree that I will be governed by the regulations of the said Institute as they are now formed, or as they may be hereafter altered; that I will advance the objects of the Institute as far as shall be in my power, and

will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can, provided that whenever I signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period), be free from this obligation.

Witness my hand this day of

Signature.

[FORM D.]

I am directed by the Council of the Mining Institute of Scotland to draw your attention to Rule VI., Section IV., and to remind you that the sum of £ of your annual subscription remains unpaid, and that you are, in consequence, in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay.

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM E.]

SIR,—I am directed by the Council of the Mining Institute of Scotland to inform you that in consequence of your arrears of subscription, and in pursuance of Rule VI., Section IV., the Council have declared by special vote, on the day of 18 , that you have forfeited your claim to belong to the Institute, and your name will be, in consequence, expunged from the Register, unless payment is made previous to 18

I am, Sir,

Yours faithfully,

Secretary.

Dated, 18

[FORM F.]

Admit
of
to the Meeting on Thursday, the
Signature of Member
The chair to be taken at Six P.M.

I undertake to abide by the regulations of the Mining Institute of Scotland, and not to aid in any unauthorised publication of the proceedings.

Signature of Visitor.

Not transferable.

The Mining Institute of Scotland.

1882-83.

HONORARY MEMBERS.

		Year of Entry.
	ALEXANDER, WILLIAM, - - - *H.M. Inspector of Mines, 23 India Street, Glasgow.*	1878
	MOORE, RALPH, - - - - *H.M. Inspector of Mines, Croft Villa, Rutherglen (President).*	1878

ORDINARY MEMBERS.

1.	ABRAHAM, DAVID, - - - - *Dowlais Iron Works, Glamorgan.*	1883
2.	ADAMS, JAMES, - - - - *Hill of Beath, Fife.*	1880
3.	AITKEN, HENRY, - - - - *Darrock, Falkirk.*	1878
4.	ALLAN, JAMES, - - - - *Garturk Colliery, Coatbridge.*	1881
5.	ALLAN, ROBERT, - - - - *Gartnavel, Maryhill.*	1880
6.	ALLAN, WILLIAM, - - - - *Woodyett and Dennymill Mines, Denny.*	1881
7.	ALLARDICE, JAMES, - - - - *Eastfield Colliery, Cambuslang.*	1881

8. ANDERSON, DAVID, - - - - 1879
Clydesdale St., Hamilton (Member of Council).

9. ANDERSON, DAVID, - - - - 1881
Little Raith Colliery, Cowdenbeath.

10. ANDERSON, GEORGE, - . - - 1880
Barkip Colliery, Dalry.

11. ANDERSON, GEORGE, - - - - 1880
Crosshill Colliery, Slamannan.

12. ANDERSON, JAMES, - - - - 1880
Farme Colliery, Rutherglen.

13. ANDERSON, JOHN, - - - - 1880
Shottstown, Pennicuick.

14. ANDERSON, THOMAS, - - - - 1881
Tannochside, Uddingston.

15. ANDREW ROBERT, - - - - 1880
Hallbeath Colliery, Dunfermline.

16. ANDREW, WILLIAM, - - - - 1880
Lassodie Colliery, Dunfermline.

17. ARCHIBALD, WILLIAM, - - - 1879
Clippens Colliery, Johnstone.

18. ARNOTT, THOMAS, - - - - 1879
Summerlee Iron Works, Coatbridge.

19. ARROL, T. ARTHUR, - - - - 1879
Clutha Iron Works, Glasgow.

20. AUSTINE, JOHN, - - - - 1878
Oak Lodge, Hamilton (Member of Council).

21. BAIN, HUGH, - - - - - 1883
Uppertown Cottage, by Airdrie.

22. BAIRD, ARCHIBALD, - - - - 1879
Park Road, Hamilton.

23. BAIRD, MATTHEW B., - - - - 1880
Charleville, Uddingston.

24. BAIRD, ROBERT, - - - - 1879
139 *St. Vincent Street, Glasgow.*

25. BALLANTYNE, JAMES, - - - 1882
Craigrigg Colliery, Woodend, Bathgate.

26. BARR, JAMES, - - - - - 1879
Longlee Colliery, Larkhall.

27. BARR, WILLIAM, - - - - 1879
Over-Dalserf Colliery, Larkhall.

28. BARROWMAN, JAMES, - - - 1879
Ardenlee, Portland Park, Hamilton (Member of Council).

29. BAXTER, ROBERT, - - - - 1880
East Benhar Colliery, Fauldhouse.

30. BEAVRIDGE, JOHN, - - - - 1881
Kelty Colliery, Blairadam.

31. BEGG, GILBERT BURNS, - - - 1878
Brandon Street, Motherwell (past President, Member of Council.)

32. BEGG, JOHN, - - - - - 1879
Whitehill Colliery, Rosewell.

33. BEITH, ROBERT, - - - - 1878
Clyde Coal Company, Hamilton.

34. BELL, JAMES, - - - - - 1881
San Fermin Mining Company, Portugalete, Bilbao.

35. BEVERIDGE, JAMES, - - - - 1882
Loanhead, Edinburgh.

36. BIRREL, GEORGE, - - - - 1880
West of Fife Coal Company, Guildhall Street, Dunfermline.

37. BISHOP, GEORGE A., - - - - 1879
10 *Bothwell Street, Glasgow.*

38. BLACKADDER, ALEXANDER, - - 1880
Stand Colliery, Airdrie.

39. BLYTH, ARCHIBALD, - - - - 1878
Bent Colliery, Hamilton (Member of Council).

40. BORLAND, THOMAS, - - - - 1880
Clyde Iron Works, Tollcross, Glasgow.

41. BORROWMAN, JAMES, - - - 1881
Wellshot Colliery, Cambuslang.

42. BOWIE, HUNTER, - - - - 1881
Lugar Iron Works, Old Cumnock.

43. BRAND, A. DOUGLAS, - - - - 1881
6 *Dixon Street, Glasgow.*

44. BROWN, GEORGE, - - - - 1880
Longriggend Colliery, Airdrie.

45. BROWN, PETER, - - - - 1881
Victoria Terrace, Dunbeth Road, Coatbridge.

46. BROWN, THOMAS M., - - - - 1880
Lanemark Colliery, New Cumnock.

47. BROWN, WILLIAM, - - - - 1883
Newton Colliery, Newton.

48. BRYDEN, DAVID, - - - - 1881
Coylton, Ayr.

49. BUCHANAN, D. C. R. C., - - - 1881
Drumpellier, Coatbridge.

50. CALDERWOOD, ROBERT, - - - 1879
Cradley, near Brierley Hill, Staffordshire.

51. CALDERWOOD, ROBERT, - - - 1880
Oakbank Shale Works, Mid Calder.

52. CAMERON, ROBERT, - - - - 1879
Priory Lodge, Blantyre.

53. CAMPBELL, ARCHIBALD, - - - 1883
Redding Collieries, Polmont Station.

54. CAMPBELL, THOMAS, - - - - 1881
Spindleside Colliery, Cleland.

55. CAMPBELL, WILLIAM, - - - - 1882
Moshannon, Sobieski, P. O., Clearfield County, Pa., America.

56. CAREY, WILLIAM, - - - - 1882
Grange Colliery, Bo'ness.

57. CARLOW, CHARLES, - - - - 1879
The Fife Coal Company, Leven.

58. CARMICHAEL, ROBERT, - - - 1880
Earnock Colliery, Hamilton.

59. CHAMBERS, WILLIAM, - - - 1880
Dalziel Saw Mills, Motherwell.

60. CHRISTISON, ROBERT, - - - 1880
Durhamtown, Bathgate.

61. CLARK, JAMES, - - - - - 1880
Linrig Colliery, Cleland.

62. CLARK, ROBERT, - - - - 1883
Arniston Colliery, Gorebridge,

63. CLARKE, J. A., - - - - - 1880
Ayr Colliery, Ayr.

64. CLELLAND, ALEXANDER, - - - 1881

65. CLELLAND, JAMES, - - - - 1879
Carronhall Colliery, Falkirk.

66. COCHRANE, NEIL, - - - - 1881
Auchinheath Colliery, Lesmahagow.

67. COLQUHOUN, JAMES, - - - - 1882
Tredegar Iron Works, South Wales.

68. COLQUHOUN, ROBERT, - - - 1882
66 *South Bridge Street, Airdrie.*

69. CONNAL, JOHN, - - - - - 1882
123 *St. Vincent Street, Glasgow.*

70. COOK, ROBERT, - - - - 1881
Church Street, Sunnyside, Coatbridge.

71. COWAN, DAVID, - - - - 1879
Carron Iron Works, Falkirk.

72. COWIE, GEORGE, - - - - 1879
Springwells Colliery, Airdrie.

73. COWIE, JAMES, - - - - 1880
Messrs Baird & Co., Kilsyth.

74. CRANSTON, DAVID, - - - - 1880
Muldron Pits, Fauldhouse.

75. CRICHTON, A. H., - - - - 1880
Uphall Mineral Oil Co., Uphall.

76. CROCKET, JOHN, - - - - 1880
Cowdenhill, Bo'ness.

77. CROOKSTON, ANDREW, - - - 1880
Wemyss Colliery, by Dysart, Fife.

78. CROOKSTON, THOMAS, - - - 1879
Shields Colliery, Motherwell.

79. CROSSLEY, WILLIAM, - - - - 1881
153 *Queen Street, Glasgow.*

80. CUNINGHAME, ALEX., - - - 1880
117 *Douglas Street, Glasgow.*

81. CUNINGHAME, J. C., - - - - 1879
127 *St. Vincent Street, Glasgow.*

82. CUNINGHAME, JOHN, - - - - 1879
127 *St. Vincent Street, Glasgow.*

83. CUNNINGHAME, ARCHIBALD, - - 1881
Eglinton Iron Co., Dalry.

84. CUTHBERT, ROBERT, - - - . 1881
Gauchalland Colliery, Galston.

85. DALZELL, JOHN B., - - - - 1881
Hill Colliery, Lesmahagow.

86. DANKS, HENRY, - - - - 1880
Green Colliery, Wishaw.

87. DARLING, JOHN, - - - - 1880
Cleugh Gas Coal Works, Forth, Lanark.

88. DEWAR, PETER, - - - - 1878
Braidwood Colliery, Carluke.

89. DEWAR, ROBERT, - - - 1881
Harthill Colliery, Whitburn.

90. DEWAR, THOMAS, - - - - 1881
Glencleland Colliery, Wishaw.

91. DICK, JAMES, - - - - - 1881
Knownoble, Wishaw.

92. DIXON, JAMES S., - - - - 1879
Bent Colliery, Hamilton (Vice-President).

93. *DANKS, FRANCIS, - - - - 1882

94. DRINNAN, JOHN, - - - - 1880
Arden Colliery, Airdrie (Member of Council).

95. DUNCAN, FREDERICK, - - - 1879
1 *Dixon Street, Glasgow.*

96. DUNCAN, GEORGE, - - - - 1881
Leven Colliery, Leven.

97. DUNN, JOHN, - - - - - 1881
Bothwell.

98. DUNN, DAVID G., - - - - 1882
Rhinds, Baillieston.

99. DURIE, JOHN, - - - - - 1880
Elphinstone Colliery, Tranent.

100. ERSKINE, GEORGE, - - - - 1881
Lochgelly, Fife.

101. FALCONER, THOMAS, - - - - 1880
Fordell Colliery, Crossgates, Fife.

102. FAULDS, ALEXANDER, - - - 1878
Burnside House, Old Cumnock.

103. FERGUSON, DAVID, - - - - 1878
Hematite Iron Works, Harrington, Cumberland.

104. FERGUSON, DUNCAN, - - - - 1880
Lochore and Capeldrae Collieries, Lochgelly.

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* Deceased.

105. FORGIE, JAMES T., - - - - 1878
Craigston Square, Lugar, Old Cumnock.

106. FRASER, WILLIAM, - - - - 1881
Uphall Mineral Oil Co., Uphall.

107. FRENCH, JOHN, - - - - 1879
Millcroft Cottage, Rutherglen Road, Glasgow.

108. FREW ROBERT, - - - - - 1879
75 *Bath Street, Glasgow.*

109. FREW, WILLIAM, - - - - 1880
Raploch Colliery, Larkhall.

110. FULTON, DAVID, - - - - 1881
Dalquharran, Maybole.

111. GALLOWAY, JOHN, - - - - 1879
Barleith and Dollar Collieries, Hurlford, Ayrshire.

112. GALLOWAY, T. LINDSAY, - - - 1880
28 *St. Enoch Square, Glasgow.*

113. GARDINER, ARCHIBALD, - - - 1880
12 *Rutland Place, Govan Road, Glasgow.*

114. GARDINER, DAVID, - - 1881
Meiklehill Colliery, Kirkintilloch.

115. GARDINER, THOMAS, JUN., - - - 1881
Auldton Collieries, Dalserf.

116. GAVIN, JAMES, - - - - - 1880
Carfin Colliery, Motherwell.

117. GEDDES, G. H., - - - - - 1881
142 *Princes Street, Edinburgh.*

118. GEMMELL, JAMES, - - - - 1878
Govan Colliery, Glasgow.

119. GIBB, ROBERT, - - - - - 1881
Pollok Colliery, Pollokshaws.

120. GILCHRIST, ARCHIBALD, - - - 1881
Polton Collieries, Bonnyrigg, near Edinburgh.

121. GILCHRIST, HUGH M., - - - 1882
Rapid City, Rock Island County, Illinois, U.S.A.

122. GILCHRIST, JAMES, - - - 1878
Earnock Colliery, Hamilton (Secretary).

123. GILLON, WILLIAM, - - - - 1881
Kinneil Iron Works, Bo'ness.

124. GILMOUR, ALLAN, - - - - 1879
Portland Colliery, Kilmarnock (Member of Council).

125. GILMOUR, DANIEL, - - - - 1881
Portland Colliery, Kilmarnock.

126. GILMOUR, JAMES, - - - - 1881
Duchray Colliery, Coylton, Ayr.

127. GILMOUR, JOSEPH, - - - - 1881
Goatfoot Colliery, Galston.

128. GLEN, ROBERT, - - - 1881
Eastfield Colliery, Cambuslang.

129. GOODWIN, JAMES, - - - - 1883
Gartness Coal Co., Airdrie.

130. GORDON, GAVIN C., - - - - 1879
Knightswood Colliery, Maryhill.

131. GRAINGER, W. N., - - - - 1879
80*a Princes Street, Edinburgh.*

132. GRANT, JOHN, - - - - - 1878
Bog and Home Farm Collieries, Larkhall.

133. GRANT, ROBERT, - - - - 1881
Limerigg Colliery, Slamannan.

134. GRANT, T. M., - - - - 1879
Townholm Engine Works, Kilmarnock.

135. GRAY, ARCHIBALD, - - - - 1883
Glengarnock Iron Works, Ayrshire.

136. GRAY, ARCHIBALD, - - - - 1881
Stanley Bank, Dalry.

137. GRAY, JAMES, - - - - - 1881

138. GRAY, JOHN, - - - - - 1882
Avon Cottage, Stonehouse.

139. GRAY, WILLIAM, - - - - 1880
Lugar Iron Works, Old Cumnock.

140. GREEN, WILLIAM, - - - - 1883
Galston Colliery, Galston.

141. GREIG, JOHN, - - - - - 1879
Tillgrie, Milnathort, Kinross.

142. GRIERSON, THOMAS, - - - - 1881
Glebe Colliery, Douglas.

143. HADDOW, JOHN, - - - - 1879
Arniston Colliery, Gorebridge.

144. HAMILTON, JOHN G. C., - - - 1881
Dalzell, Motherwell.

145. HAMILTON, ROBERT, - - - - 1880
Harbour Buildings, Ardrossan.

146. HAMILTON, THOMAS, - - - - 1879
11 *Coal Exchange, Glasgow.*

147. HARDIE, JAMES, - - - - 1882
Benhar, Whitburn.

148. HART, JAMES, - - - - - 1880
Duchray Colliery, by Ayr.

149. HART, JOHN, - - - - - 1881
Clyde Iron Works, Tollcross.

150. HASTIE, JAMES, - - - - 1879
Greenfield Colliery, Hamilton. ***(Member of Council.)***

151. HASTIE, WILLIAM, - - - 1881
Gilmilnscroft, Auchinleck.

152. HENDERSON, ANDREW, - - - 1880
Muiravonside Colliery, Bowhouse, Linlithgow.

153. HENDRIE, JOHN, - - - - 1881
82 *West Regent Street, Glasgow.*

154. HERD, PETER, - - - - - 1880
Dunnikeir Colliery, Kirkcaldy.

155. HERD, THOMAS, - - - - 1880
Dunnikeir Colliery, Kirkcaldy.

156. HILL, JAMES, - - - - - 1880
Clyde Coal Co., Hamilton.

157. HILL, LAURENCE, - - - - 1883
59 *St. Vincent Street, Glasgow.*

158. HODSON, JAMES, - - - - 1880
Liverpool Road, St. Helens, Lancashire.

159. HOGG, JOHN, - - - - - 1880
North Motherwell Colliery, Motherwell (Member of Council).

160. HOGG, WILLIAM, - - - - 1881
Carnmoor Cottage, Forth, by Lanark.

161. HOOD, ARCHIBALD, - - - - 1879
6 *Bute Crescent, Cardiff.*

162. HOWIE, JAMES, - - - - 1883
Newton Colliery, Newton.

163. HUNTER, A., - - - - - 1880
Alloa Colliery, Alloa.

164. HUNTER, ANDREW, - - - - 1878
Orbiston Colliery, Bellshill.

165. HURLL, MARK, - - - - - 1880
Glenboig, Coatbridge.

166. HUSBAND, JOHN, - - - - 1881
Biggart Cottage, Lugton, by Beith.

167. HUTCHISON, JOSEPH, - - . - 1881
Woodside Colliery, Dalserf.

168. HYSLOP, JONATHAN, - - - - 1881
Kinneil Iron Works, Bo'ness (Member of Council).

169. IRELAND, THOMAS, - - - - 1881
Largoward, Kilconquhar, Fife.

170. IRVINE, C. M'LAREN, - - - - 1880
Fence Colliery, Blackwood, Lesmahagow.

171. JACKSON, DOUGLAS, - - - - 1880
Ponfeigh, Douglas.

172. JAMIESON, ALEXANDER, - - - 1878
Fairview Cottage, Bellshill.

173. JAMIESON, ANDREW, - - - - 1881
College of Science and Arts, Glasgow.

174. JAMIESON, CRAWFORD, - - - 1880

175. JAMIESON, ROBERT, - - - - 1881
Polkemmet Cottage, Bathgate.

176. JAMIESON, ROBERT, - - - - 1880

177. JAMIESON, WILLIAM, - - - - 1879
Addiewell Oil Works, West Calder.

178. JEFFREY, ANDREW, - - - - 1880
Rankinston Colliery, Patna.

179. JENKINS, JAMES G., - - - - 1882
33 *Renfield Street, Glasgow.*

180. JOHNSTONE, DAVID, - - - - 1881
12 *York Street, Glasgow.*

181. JOHNSTONE, RONALD H., - - - 1879
75 *West Nile Street, Glasgow.*

182. JOHNSTONE, HUGH, - - - - 1879
Garscadden Works, Bearsden.

183. JOHNSTONE, THOMAS, - - - 1880
Bothwell Collieries, Bothwell.

184. KENNEDY, ALEXANDER, - - - 1882
Broxburn Oil Works, Broxburn,

185. KERR, ARCHIBALD, - - - - 1881
Barncluith Colliery, Hamilton.

186. KERR, ARCHIBALD, - - - - 1881
21 *John Street, Hamilton (Librarian).*

187. KIRKWOOD, ARCHIBALD, - - - 1878
Dalzell Colliery, Motherwell.

188. KIRKWOOD, WILLIAM, - - - 1880
Inkerman Works, Paisley.

189. KNOX, JAMES, - - - - - 1880
Allanton Colliery, Newmains.

190. LANGLANDS, JOHN, - - - - 1878
Carfin Colliery, Motherwell.

191. LAW, ALEXANDER, - - - - 1880
5 *Millbrae Terrace, Langside.*

192. LEGAT, A. S., - - - - - 1879
Loanhead Colliery, Edinburgh.

193. LEGGETE, JOHN, - - - 1881
Birkenshaw, Larkhall.

194. LEWIN, HENRY W., - - - - 1882
Drumpellier, Coatbridge.

195. LITHGOW, THOMAS, - - - . 1882
Langbyres Colliery, Omoa, Motherwell.

196. LIVINGSTONE, ARCHIBALD, - - - 1880
Glencavil, Ballymena, Ireland.

197. LOUDON, JOHN, - - - - 1879
Burntisland Oil Co., Burntisland.

198. LOVE, JOHN, - - - - - - 1882
Portland Iron Works, Hurlford.

199. LOVE, JOHN, - - - - - - 1878
Haughhead Colliery, Hamilton (Member of Council).

200. LOVE, WILLIAM, - - - 1881
Shotts Iron Coy., Shotts.

201. MACKENZIE, WILLIAM, - - - 1880
Newbattle Collieries, Dalkeith,

202. MAKEPEACE, HUGH R., - - - 1881
Calderbank, Airdrie.

203. MALCOLM, JAMES, - - - - 1879
Craigneuk Colliery, Motherwell.

204. MARSHALL, R. A., - - - - 1879
170 *Hope Street, Glasgow.*

205. MARTIN, ROBERT, - - - - 1879
Pentland Oil Works, Loanhead.

206. MARTIN WILLIAM, - - - - 1881
Douglas Park Colliery, Bellshill.

207. MATHIE, JAMES, - - - - 1879
Cornsilloch and Millburn Collieries, Larkhall.

208. MAXWELL, JAMES, - - - - 1882
Burnbank, Hamilton.

209. MEIKLEJOHN, JOHN, - - - 1879
Westfield Iron Works, Dalkeith.

210. MILLER, ARCHIBALD, - - - - 1881
Wood Merchant, Motherwell.

211. MITCHELL, GEORGE A., - - - 1881
67 *West Nile Street, Glasgow.*

212. MITCHELL, JAMES F., - - - - 1881

213. MOFFAT, PETER, - - - - 1881
16 *Ure Place, Montrose Street, Glasgow.*

214. MOODIE, THOMAS, - - - - 1881
Devon Colliery, Alloa.

215. MOORE ROBERT T., - - - - 1880
Croft Villa, Rutherglen.

216. MORISON, JOHN, - - - - 1879
Newbattle Collieries, Dalkeith.

217. MORTON, JAMES, - - - - 1880
Langloan Iron Works, Coatbridge.

218. MORTON, JOHN, - - - - 1880
Auchenharvie Colliery, Saltcoats.

219. MORTON, R. M., - - - - 1879
Clydeford House, Cambuslang.

220. MUIR, THOMAS, - - - - 1881
Auchinlea Colliery, Cleland.

221. MUIR, W. W., - - - - - 1878
Coltness Colliery, Newmains.

222. MUNGALL, HENRY, - - - - 1880
Cowdenbeath Collieries, Cowdenbeath.

223. MUNRO, JAMES, - - - - 1879
Quarter Iron Works, Hamilton.

224. MUNROE, H. S., - - - - 1881
H. Grevel, 33 King Street, Covent Garden, London, W.C.

225. MURRAY, JOHN, - - - - 1879
Greengairs, Airdrie.

226. M'BETH, PETER, - - - - 1879
Callander Coal Co., Falkirk.

227. M'CAIRN, NICOL, - - - - 1881
Prestonlinks, Prestonpans.

228. M'CALLUM, ALEXANDER, - - - 1880
Benhar Coal Co. (Limited), Portobello.

229. M'COSH, ANDREW K., - - - 1881
Gartsherrie Iron Works, Coatbridge,.

230. M'CREATH, GEORGE W., - - - 1880
95 *Bath Street, Glasgow.*

231. M'CREATH, JAMES, - - - - 1879
95 *Bath Street, Glasgow (past Vice-President).*

232. M'CULLOCH, JOHN, - - - - 1879
Solsgirth Colliery, Kirkintilloch.

233. M'CULLOCH, WILLIAM, - - - 1881
Linkieburn House, Muirkirk.

234. M'DONALD, JOHN, - - - - 1880
Greenhill Colliery, Holytown.

235. MACDONALD, JOHN, - - - - 1879
Haughhead Colliery, Hamilton.

236. MACDONALD, SYMINGTON, - - -

237. M'FARLANE, MALCOLM, - - - 1878
Glendufjhill Colliery, Shettleston.

238. M'FARLANE, WALTER, - - - 1882
12 *Whitefield Road, Govan.*

239. M'FEDDRIS, WILLIAM, - - - 1880
Tannochside Colliery, Uddingston.

240. M'GEE, JOHN, - - - - - 1880
Tillicoultry Colliery, Tillicoultry.

241. M'KAY, ANDREW, - - - - 1879
Grangemouth Coal Co., Grangemouth.

242. M'KAY, JAMES, - - - - 1880
Spittalhill Colliery, Newton.

243. M'KENZIE, KENNETH, - - - 1880
New Bank Colliery, New Cumnock.

244. M'KILLOP, ARCHIBALD, - - - 1880
Muiravonside Colliery, Linlithgow.

245. M'LAREN, ROBERT, - - - - 1882
Braehead and Newlands Collieries, Baillieston.

246. M'LAUCHLAN, J. D., - - - - 1882
Viewforth Manse, Edinburgh.

247. M'LEAN, ANDREW, - - - - 1880
Hill Colliery, Lesmahagow.

248. M'NAB, JOHN, - - - - - 1881
Flemington Coal Co. (Limited), Cambuslang.

249. M'NAUGHTON, JAMES, - - - 1880
11 *West Regent Street, Glasgow.*

250. M'NEIL, JAMES, - - - - 1878
Maryville Colliery, Uddingston.

251. M'NEIL, ROBERT, - - - - 1878
Blackhill Colliery, Bishopbriggs, Glasgow.

252. M'PHERSON, GILBERT, - - . 1881
Trabbock Colliery, Coylton, Ayr.

253. M'VICAR, HAMILTON, - - - 1880
Monkland Iron and Coal Works, Airdrie.

254. NASMYTH, A.. - - - - - 1880
Donibristle Colliery, Crossgates, Fife.

255. NASMYTH, A. H., - - - - 1880
Donibristle Colliery, Crossgates, Fife.

256. NASMYTH, J. A., - - - - 1880
Donibristle Colliery, Crossgates, Fife.

257. NEILSON, BENJAMIN, - - - - 1880
Niddrie Colliery, Portobello.

258. NEILSON, GEORGE, - - - - 1883
Summerlee Iron Works, Coatbridge.

259. NEILSON, JOHN, - - - - 1883
Summerlee Iron Works, Coatbridge.

260. NEISH, GEORGE, - - - - 1879
49 *Bardowie Street, Possil Park, Glasgow.*

261. NESS, HENRY, - - - - - 1880
Muircockhall Colliery, Dunfermline.

262. NIMMO, THOMAS, - - - - 1879
Fauldhouse Colliery, Fauldhouse.

263. ORMISTON, A. R., - - - - 1880
95 *Bath Street, Glasgow.*

264. ORMISTON, JAMES, - - - - 1880
Castlehill Iron Works, Carluke.

265. ORR, THOMAS, - - - - - 1881
Morningside Colliery, Newmains.

266. PARK, JOHN, - - - - - 1881
Stonelaw Colliery, Rutherglen.

267. PARK, JOSEPH, - - - - - 1879
Allanshaw Colliery, Hamilton.

268. PATERSON, HUGH, - - - - 1881
Braidhurst Colliery, Motherwell.

269. PATERSON, JOHN, - - - - 1880
Oak Villa, Uddingston.

270. PAUL, JAMES, - - - - - 1881
Law Colliery, Carluke.

271. PAUL, JAMES, - - - - - 1879
Wilsontown House, Wilsontown.

272. PENMAN, WILLIAM M., - - - 1881
Blairingone Colliery, Dollar.

273. PERCY, C. M., - - - - - 1882
25 *King Street, Wigan.*

274. PETTIGREW, ROBERT, - - - 1881
66 *Flowerhill Street, Airdrie.*

275. PHILIPS, JOHN, - - - - 1880
Braidwood, Carluke.

276. PITCAIRN, GILBERT, - - - - 1880
Eddlewood Colliery, Hamilton.

277. POLLOCK, WILLIAM, - . - - 1883
88 *Great Clyde Street, Glasgow.*

278. PRATT, GEORGE, - - - - 1879
29 *Waterloo Street, Glasgow.*

279. PRENTICE, JAMES, - - - - 1881
Stanrigg Collieries, Airdrie.

280. PRENTICE, JOSEPH, - - - - 1880
Addiewell Colliery, West Calder.

281. PRENTICE, WILLIAM, - - - - 1879
Dalmellington Iron Co., Ayrshire.

282. PRENTICE, THOMAS, - - - - 1879
Addiewell Works, West Calder.

283. PRINGLE, JAMES, - - - - 1880
Govan Colliery, Glasgow.

284. RANKINE, DAVID, - - - - 1879
75 *West Nile Street, Glasgow.*

285. RANKIN, JOHN, JUN., - - - 1881
Drumgray Colliery, Airdrie.

286. REID, ALEX. G., - - - - 1878
Quarter Iron Works, Hamilton.

287. REID, JOHN, - - - - - 1881
Loanhead House, Baillieston.

288. RIGG, ALEXANDER, - - - - 1880
Dykehead Colliery, Hurlford.

289. RITCHIE, ALEX. - - - - 1881
Cleland Colliery, Newarthill.

290. ROBERTSON, ALEX., - - - - 1880
Benwhat, Dalmellington.

291. ROBERTSON, ARCHD., - - - - 1880
Bathville Colliery, Armadale.

292. ROBERTSON, DAVID, - - - - 1881
Dalquharran Colliery, Maybole.

293. ROBERTSON, DAVID, - - - - 1880
21 *Pitt Street, Glasgow.*

294. ROBERTSON, D. A. W., - - - 1882
Glenbank, Lenzie.

295. ROBERTSON, JAMES, - - - - 1881
Braehead, Baillieston.

296. ROBERTSON, JOHN, - - - - 1880
Haycood Colliery, Lanark.

297. ROBERTSON, JOHN, - - - - 1880
Lanemark Colliery, New Cumnock.

298. ROBERTSON, ROBERT, - - - 1882
59 *Graham Street, Airdrie.*

299. ROBERTSON, WILLIAM, - - - 1879
123 *St. Vincent Street, Glasgow.*

300. ROBINSON, EDWIN, - - - - 1879

301. ROBSON, J. T., - - - - - 1878
Cambuslang (Vice-President).

302. ROBSON, ROBERT, - - - - 1882
Breich Shale Pits, West Calder.

303. RONALDSON, JAMES H., - - - 1879
Trabboch Colliery, Coylton, Ayr.

304. RONALDSON, JOHN M., - - - 1879
Belton Villa, Pollokshields (Vice-President).

305. ROSS, ALEXANDER, - - - - 1880
Glenhead, Camp, Motherwell.

306. ROSS, JOHN, - - - - - 1882
Benhar School, Whitburn.

307. ROSS, JAMES, - - - - - 1878
Rosemount Cottage, Mid Street, Bathgate.

308. ROSS, MICHAEL, - - - - 1878
Clyde Bridge, Hamilton, (Treasurer).

309. ROWAN, HENRY, - - - - 1881
Avondale Cottage, Uddingston.

310. ROXBURGH, ALEXANDER, - - - 1880
Alloa Coal Company, Alloa.

311. ROY, WILLIAM, - - - - - 1879
Limerig and West Drumclair Collieries, Slamannan.

312. RUSSELL, ALEXANDER, - - - 1883
Dalmeny, Edinburgh.

313. RUSSELL, ARCHIBALD, Jun., - - - 1882
Roslin, Bothwell.

314. RUSSELL, JAMES, - - - - 1880
Elgin and Wellwood Collieries, Dunfermline.

315. RUSSELL, ROBERT, - - - - 1878
Coltness Iron Works, Newmains.

316. RUSSELL, W. S., - - - - 1880
Armadale Colliery, Armadale, by Bathgate.

317. SCHUMAN, SIG., - - - - 1880
4 North Court, Royal Exchange, Glasgow.

318. SCOBIE, WILLIAM, - - - - 1881
Barr Colliery, Beith.

319. SCOTT, JOHN, - - - - - 1879
Calder Iron Works, Coatbridge.

320. SEMPLE, WILLIAM, Jun., - - - 1880
Crosby and Gilcruix Collieries, Maryport, Cumberland.

321. SEMPLE, WILLIAM, Sen., - - - 1881
Goatfoot Colliery, Galston.

322. SHARP, A., - - - - - - 1880
Omoa and Cleland Iron and Coal Co., Motherwell.

323. SHARPE, GEORGE, - - - - 1881
Wilsontown Colliery, Lanark.

324. SIMPSON, ALEXANDER, - - - 1878
Albert Road, Pollokshields.

325. SIMPSON, DUNDAS, - - - - 1879
Souterhouse Colliery, Coatbridge.

326. SIMPSON, JAMES, - - - - 1881
Flemington Coal Company, Cambuslang.

327. SLOSS, JAMES, - - - - - 1881
Auchlochan Collieries, Lesmahagow.

328. SMART, JAMES, - - - - - 1879
Angus Lodge, Hamilton (Vice-President).

329. SMITH, HAMILTON, - - - - 1878
Cadzow Colliery, Hamilton.

330. SMITH, JAMES, - - - - - 1881
Blantyre Colliery, High Blantyre.

331. SMITH, JOHN, - - - - - 1878
Cannock Lodge Colliery, Bloxwick, Staffordshire.

332. SMITH, JOHN, - - - - - 1880
Rosehall Colliery, Coatbridge.

333. SOMMERVILLE, WILLIAM, - - - 1880
Bredisholm Colliery, Uddingston.

334. SPEIRS, ALEXANDER, Jun., - - - 1879
28 *St. Enoch Square, Glasgow.*

335. SPOWART THOMAS, - - - - 1881
Broomhead, Dunfermline (Member of Council).

336. STEVENSON, GRAHAM, - - - 1879
Airdrie Engine Works, Airdrie.

337. STEVENSON, JOHN, - - - - 1881
Lilliehill House, Dunfermline.

338. STEWART, ALEX., - - - - 1879
Tharsis Mines, Huelva, Spain.

339. STEWART, H., - - - - - 1881
Tranent Colliery, Tranent.

340. STIRLING, JOHN, - - - - 1880
Banknock Colliery, Denny.

341. STIRLING, WALTER, - - - - 1880
Rawyards, Airdrie.

342. STRAIN, HUGH, - - - - 1879
3 *Clark Street, Airdrie.*

343. STURROCK, JOHN G., - - - - 1881
Skerrington Colliery, Hurlford.

344. TAYLOR, LACHLAN, - - - - 1879
Brass Foundry, Hamilton.

345. TELFER, HENRY, - - - - 1878
Overtown Colliery, Wishaw (Member of Council).

346. TENNANT, JOHN, - - - - 1880
Auchingramont, Hamilton.

347. TENNANT, ROBERT, - - - - 1881
Springbank Colliery, Airdrie.

348. TERRIS, HENRY, - - - - 1880
Clackmannan Colliery, Clackmannan.

349. THOM, ARCHIBALD, - - - - 1881
Bothwell Park Colliery, Bothwell.

350. THOMAS, DAVEY, - - - - 1881
Cowdenbeath, Fife.

351. THOMAS, SHENTON, - - - - 1879
Blantyre Collieries, High Blantyre.

352. THOMSON, ABRAM, - - - - 1880
Hareleeshill, Larkhall.

353. THOMSON, ALEX., - - - - 1880
Springbank Colliery, Airdrie.

354. THOMSON, A. M'D., - - - - 1880
West Limerigg Colliery Co., Slamannan.

355. THOMSON, CHARLES, - - - - 1879
Calder Iron Works, Coatbridge.

356. THOMSON, JOHN, - - - - 1880
Stevenston Colliery, Holytown.

357. THOMSON, RICHARD, - - - - 1878
186 *Saracen Street, Possil Park, Glasgow.*

358. THOMSON, SAMUEL, - - - - 1879
Jerviston House, Motherwell.

359. THOMSON, THOMAS, - - - - 1879
Balquhatston Colliery, Slamannan.

360. THORNTON, PETER, - - - - 1878
Crofthead, Fauldhouse.

361. *THORNTON, THOMAS, - - - - 1878

362. THORNTON, THOMAS, JUN., - - - 1879
Auchinheath Colliery, Lesmahagow.

363. TOPPING, R. M., - - - - 1879
Blantyre Foundry, Blantyre.

364. TORRANCE, JAMES W., - - - 1881
69 *Buchanan Street, Glasgow.*

365. TURNER, WILLIAM, - - - - 1881
Chapel Colliery, Newmains.

366. TWADDLE, WILLIAM, - - - - 1878
Ferniegair, Hamilton.

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*Deceased.

367. URE, JOHN Y., - - - - - 1879
Udston Colliery, Hamilton.

368. WADDELL, JAMES, - - - - 1879
Mauldslie Colliery, Carluke.

369. WADDELL, ROBERT, - - - - 1880
Blackston Works, Paisley.

370. WALDIE, JAMES, - - - 1882
Tranent Collieries, Tranent.

371. WALKER, DAVID, - - - - - 1880
Ellismuir and Calderbank Colliery, Baillieston.

372. WALKER, JAMES P., - - - - 1880
Dalmellington Iron Works, Ayrshire.

373. WALKER ROBERT, - - - - 1881
Tannochside, Uddingston.

374. WALKER, WILLIAM H., - - 1880
3 *Kerseland Street, Hillhead, Glasgow.*

375. WALKER, WILLIAM, - - - 1880
Rigside Colliery, Douglas.

376. WALLACE, JAMES, - - - - 1882
Wester Gartshore Colliery, Kirkintilloch.

377. WALTON, J. COULTHARD, - - - 1881
So. Benwell Colliery, Newcastle-on-Tyne.

378. WARDLAW JOHN, - - - - 1878
Garriongill Colliery, Wishaw.

379. WARDROP, JOHN, - - - - 1879
Woodside Colliery, Carluke.

380. WATSON, JOHN, - - - - 1879
Earnock, Hamilton.

381. WATSON, THOMAS, JUN., - - 1880
Craignethan Colliery, Lanark.

382. WEBSTER, DAVID, - - - - 1880
Burdie House Lime Works, Edinburgh.

383. WEIR, ALEXANDER, - - - - 1881
Plains, Airdrie.

384. WEIR, WILLIAM, - - - - 1881
Caldercruix, Airdrie.

385. WHITELAW, THOMAS, - - - 1879
Dalziel Colliery, Motherwell.

386. WILLIAMS, THOMAS E., - - - 1880
Camp Colliery, Motherwell.

387. WILLIAMSON, JAMES, - - - 1880
M'Lean's Land, Dunbeth road, Coatbridge.

388. WILLIAMSON, JOHN R., - - - 1882
12 *St. Andrew Square, Edinburgh.*

389. WILSON, ANDREW, - - - - 1880
Dalzell Estate Office, Motherwell.

390. WILSON, ANDREW M., - - - 1880
Glorat, Milton of Campsie.

391. WILSON, JAMES, - - - - 1880
Woodend Colliery, Armadale, Bathgate.

392. WILSON, JOHN, - - - - 1881
Alderston, Mid-Calder.

393. WILSON, JOHN, - - - - 1879
Dechmont Lodge, Bothwell.

394. WILSON, ROBERT, - - - - 1880
Longrigg Colliery, Slamannan.

395. WILSON, ROBERT, - - - - 1880
Eastgrange, by Culross.

396. WILSON, THOMAS, - - - - 1880
Eastplean Colliery, Bannockburn.

397. WILSON, WILLIAM, - - - - 1879
Auchinraith Colliery, High Blantyre.

398. WILSON, WILLIAM, - - - - 1880
Dykehead Colliery, Larkhall.

399. WILSON, WILLIAM, - - - - 1881
The Cottage, Uphall.

400. WILSON, WILLIAM, - - - - 1883
Walmer House, Dunfermline.

401. WINGATE, DAVID, - - - - 1879
11 *Prince Edward Street, Govanhill, Glasgow.*

402. WINNING, ANDREW, - - - - 1882
New Farme Colliery, Rutherglen.

403. WOOD, JAMES, - - - - - 1880
40 *St. Enoch Square, Glasgow.*

404. WYLLIE, JAMES, - - - - 1880
Townhill Colliery, Dunfermline.

405. WYPER, JAMES, - - - - 1880
Mauldslie Colliery, Carluke.

406. YATES, ANDREW, - - - - 1881
Bellfield Colliery, Hurlford.

407. YOUNG, JAMES, - - - - 1882
Quarter Iron Works, Hamilton.

408. YOUNG, JOHN, - - - - - 1881
Baljaffray Colliery, New Kilpatrick.

409. YOUNG, ROBERT, - - - - 1880
Thankerton Colliery, Holytown.

410. YOUNG, ROBERT, - - - - 1882
37 *West George Street, Glasgow.*

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97-98. Iron Trade Association, British—Annual Reports. 1878, 1880-82.

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105–107. Mechanical Engineers, Institution of Transactions—1879, 1880, 1881.

108, 109, Mechanical Engineers, American Society of Transactions—1880, Vol. I.

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